National Library
of Canada

Bibliothèque nationale
du Canada

Canadian Theses Service

Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

NL-339 (r. 88/04) c

Canada

UNIVERSITY OF ALBERTA

THE ASSOCIATION OF RIGHT HAND CHARACTERISTICS AND PRACTICE HABITS WITH THE PREVALENCE OF OVERUSE INJURY AMONG PIANO STUDENTS

BY

©

DAVID ONG

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

DEPARTMENT OF PHYSICAL THERAPY

EDMONTON, ALBERTA
FALL, 1992

National Library of Canada
Bibliothèque nationale du Canada

Canadian Theses Service
Service des thèses canadiennes

Ottawa, Canada
K1A 0N4

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-77051-1

Canada

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR : Mr. David Y. Ong

TITLE OF THESIS : The Association of Right Hand Characteristics and Practice Habits with the Prevalence of Overuse Injury Among Piano Students

DEGREE : Master of Science

YEAR THIS DEGREE GRANTED : 1992

Permission is hereby granted to the University of Alberta Library to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves all other publication and other rights in association with the copyright in the thesis, and except as hereinbefore provided neither the thesis nor any substantial portion thereof may be printed or otherwise reproduced in any material form whatever without the author's prior written permission.

David Ong

David Ong
1656 Grand Boulevard
North Vancouver, B.C.
V7L 3Y1

Sept. 22, 1992
DATE

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled THE ASSOCIATION OF RIGHT HAND CHARACTERISTICS AND PRACTICE HABITS WITH THE PREVALENCE OF OVERUSE INJURY AMONG PIANO STUDENTS submitted by MR. DAVID ONG in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE IN PHYSICAL THERAPY.

DR. DAVID MAGEE

DR. STEPHAN LEMELIN

Sharon Warren
DR. SHARON WARREN

Sept. 16, 1992
DATE

ABSTRACT

Piano students, like any other musicians, experience overuse injuries. This study was a cross-sectional study that examined some of the various factors that might be associated with overuse injury among piano students. One of the intentions of this study was to investigate the prevalence rate of overuse injury among piano students in the Edmonton, Alberta area. The right hand characteristic factors which included grip and finger tip pinch strength and endurance as well as hand span measurements were investigated. Various other factors which included gender, age, years of piano playing, length & frequency of piano practice, rest periods taken within each practice session, involvement in sports or recreational activities, hand positioning & playing technique, and habit of practicing through pain were also examined.

Piano student volunteers were recruited from 5 post-secondary institutions in the Edmonton area. The subjects' right hand characteristics were measured and they were interviewed by the author based on a prepared questionnaire to determine their practice characteristics.

Out of a total sample pool of 107 potential students, 62 (57.94%) responded. Three subjects were excluded due to age limitation and another five were excluded due to isolated left hand symptomatology. Fifty-four subjects were analyzed and an overuse injury prevalence rate of 53.7% was determined.

The results of this study did not show any association between the right hand characteristics with overuse injury except for male hand stretch which was found to be a factor that might lend some protection against the development of overuse injury. When logistic regression was used to examine the right hand characteristics, no statistical significance was noted. The other factors were examined with the use of the T and the Chi-Square tests, however none were found to be significantly different between the overuse and non-overuse groups except for the habit of practicing through pain which was significantly higher for the overuse group of piano students.

The various symptomatology of piano playing related overuse injury were also discussed along with some of the piano playing characteristics employed by the subjects.

ACKNOWLEDGEMENTS

I would like to thank Dr. David Magee, Dr. Sharon Warren, and Dr. Stephan Lemelin for all their invaluable assistance, support, and encouragement in the development of this thesis paper. Without their wonderful insights, I am sure the completion of this thesis would not have been possible.

I would also like to thank the piano professors Charles Austin, Helmut Brauss, Barry Bromley, Stephan Lemelin, Joachim Segger, and Diana Wiens for their support and assistance in recruiting their piano students.

I would also like to take this opportunity to thank the faculty members, support staff and fellow students at the Faculty of Rehabilitation Medicine, University of Alberta for making my stay here full of enjoyable memories.

Finally, to the Lord God Almighty, thank you for making this possible.

TABLE OF CONTENTS

CHAPTER I - INTRODUCTION........................ 1

- A. TheProblem...................................... 1
- B. Objectives...................................... 4
- C. Research Hypothesis........................... 5
- D. Definitions..................................... 6
- E. Limitations..................................... 8
- F. Delimitations................................... 9

CHAPTER II - LITERATURE REVIEW.................. 10

- I. General Medical Problems Encountered by Instrumental Musicians.................. 10
  - A. Classes of Performance Related Problems for Instrumental Musicians.............. 11
    - A 1. Focal Dystonia..................... 11
    - A 2. Nerve Entrapment Syndrome.......... 12
    - A 3. Musculoskeletal Overuse Injuries... 13
- II. The Pianist and Overuse Injuries............. 15
  - A. Areas of Affectation and Clinical Findings....................... 15
  - B. Predisposing Factors that Lead to Overuse Injuries among Pianist.......... 17
    - B 1. Extrinsic Factors.................. 18
      - B 1 a. The Instrument.............. 18
      - B 1 b. Different Hand Positions and Techniques........... 19
      - B 1 c. Time and Intensity of Practice................. 25
      - B 1 d. Experience / studentship.... 26
    - B 2. Intrinsic Factors.................. 27
      - B 2 a. Gender...................... 27
      - B 2 b. Flexibility................. 27
      - B 2 c. Upper Extremity Strength and the Pianist.......... 29
- III. Summary.................................... 32

CHAPTER III - METHODS........................... 33

- I. The Pilot Study.............................. 33
- II. The Study................................... 33
  - A. Study Design............................. 33
  - B. Study Participants....................... 34
  - C. Data Collection.......................... 36
  - D. Statistical Analysis..................... 40

CHAPTER IV - RESULTS.......................... 41

I. Demographic Information...................... 41
II. Overall Prevalence........................... 42
III. Characteristic Features of the Volunteer Students.......................... 43
IV. Overuse Injury and Right Hand Characteristics.......................... 45
V. Overuse Injury and Other Factors............. 56
  (1) Gender.................................... 56
  (2) Age....................................... 57
  (3) Years of Piano Playing.................... 58
  (4) Length and Frequency of Piano Practice.......................... 59
  (5) Rest Periods Taken Within Each Practice Session........................ 62
  (6) Involvement in Sports or Recreational Activities................. 64
  (7) General Techniques and Characteristics of Piano Playing........................ 65
    7 A. Playing Style and Mechanics........ 65
    7 B. Characteristics of Piano Playing... 69
  (8) Habit of Practicing with Pain............ 71

CHAPTER V - DISCUSSION......................... 73

Response Rate.................................. 73
Prevalence..................................... 74
Demographic Characteristics.................... 75
Clinical Signs and Symptoms.................... 76
Right Hand Characteristics..................... 77
Overuse Injury and Other Possible Factors......... 79
Relevance...................................... 84

CHAPTER VI - CONCLUSION........................ 86

Conclusion..................................... 86
Recommendation................................. 88
Clinical Significance.......................... 88

REFERENCES..................................... 90

APPENDIXES... 98
- Appendix A - Prevalence of Non-musculoskeletal Problems Reported by Orchestra members at the 1986 ICSOM Survey............. 98
- Appendix B - Clinical Findings of Overuse Injuries in Pianist.......... 99
- Appendix C - Letter of Support....................100
- Appendix D - Volunteer Information Sheet..........101
  - - Consent Form.........................102
- Appendix E - Mean Grip and Tip Pinch Strength by Mathiowetz et al(1985a)...........103
- Appendix F - Questionnaire........................104
- Appendix G - Raw Data.............................109

LIST OF TABLES

CHAPTER I

Table I - Validity and Reliability of the Jamar Dynamometer and Pinch Meter as Reported by Mathiowetz et al. (1984)................ 8

CHAPTER III

Table 1 - Volunteers from 5 Different Institutions........................... 41
Table 2 - Characteristic Features Between Overused and non-overused students...... 43
Table 3 - Clinical Manifestations of the Overused Group.......................... 44
Table 4 - Right Hand characteristics for Males.... 45
Table 5 - Right Hand Characteristics for Females.. 46
Table 6 - T-Test Analysis : Right Hand Stretch ... 47
Table 7 - T-Test Analysis : Right Hand Span....... 47
Table 8 - T-Test Analysis : Right hand Grip Strength.............................. 48
Table 9 - T-Test Analysis : Tip Pinch Strength Right Index Finger..................... 49
Table 10 - T-Test Analysis : Tip Pinch Strength Right Middle Finger.................... 50
Table 11 - T-Test Analysis : Tip Pinch Strength Right Ring Finger...................... 50
Table 12 - T-Test Analysis : Tip Pinch Strength Right Little Finger.................... 51
Table 13 - T-Test Analysis : Right Grip Endurance.. 52
Table 14 - T-Test Analysis : Right Hand Index Finger Tip Pinch Endurance............. 53
Table 15 - Logistic Regression : Overuse with Right Hand Characteristics............. 54
Table 16 - Chi-Square Analysis : Gender........... 56
Table 17 - T-Test Analysis : Age.................. 57
Table 18 - T-Test Analysis : Years of Piano Playing............................... 58
Table 19 - T-Test Analysis : Length of Piano Practice.............................. 59
Table 20 - T-Test Analysis : Frequency of Piano Practice.............................. 61
Table 21 - Chi-Square Analysis : Rest Periods Taken Within Practice Session........... 63
Table 22 - Chi-Square Analysis : Involvement in Sports/Recreation...................... 64
Table 23 - Chi-Square Analysis : Finger Joint Position.............................. 66
Table 24 - Chi-Square Analysis : Hand & Finger Tension............................... 68
Table 25 - General Techniques and Characteristics of Piano Playing...................... 70
Table 26 - Chi-Square Analysis : Habit of Practicing with Pain.................. 72

CHAPTER I

INTRODUCTION

A. THE PROBLEM

Music has been an inherent part of man's culture since the early times. The art of music making has evolved through the centuries from beating on logs for rhythm to the use of sophisticated instruments for the production of pleasing sounds called "music".

There are a variety of musical instruments in use today, and a visit to a symphony orchestra concert would expose one to some of the various instruments. Instrumental musicians, like any other professionals, also encounter physiological disorders. Since the 1980's, the medical community's interest has increased and it has been well recognized that occupational maladies encountered by musicians can be grouped into three categories : focal dystonia, nerve entrapments, and musculoskeletal overuse injuries (Hochberg et al, 1983; Knishkowy, 1986; Hoppman & Patrone, 1989; Mandel, 1990). Majority of the case reports and surveys published to date dealt with musculoskeletal injuries (Harman,1991 ; Branfonbrener, 1991) and it was these injuries that were investigated in this study.

The term "overuse injury" has been loosely applied by both health professionals and lay people alike to imply disorders wherein pain and loss of normal function resulted when any part of the body is driven over its physiological limits due to repetitive movement.

Past research had shown that hand flexibility was a significant factor in the development of overuse injuries (Wagner, 1987 ; Lee, 1990). As musicians, especially pianists, play their instruments, they often have to stretch their fingers far apart. However, there have been successful virtuosos who have quite a small hand size yet experience no overuse problems. On the other hand, there were reported cases where hypermobility has led to overuse injuries (Bird,1981 ; Larsson et al, 1987).

Fry (1987) pointed out other factors which might lead to overuse injuries including : (1) genetics, (2) technique, and (3) time combined with intensity of practice. These points were substantiated by past research which showed the development of injury coinciding with an increase in practice due to upcoming performances or examinations ; a change in teacher or repertoire; and sex, with more cases being reported among females than males.

Manchester (1988) raised the point that strength might be a factor as he suggested that males, with stronger upper body strength might have had more protection against developing overuse discomfort than females. This specific area has not been thoroughly investigated as it is widely believed among musicians that it is not the strength of the individual muscles of the hand that is most important in piano technique, but the coordination and dexterity of the hand (Wagner, 1988b).

However, the stronger a muscle, the more work it is able to do. Also, stronger muscles can endure longer at a given task (Westcott, 1987). Therefore, with the repetitive type of work done by the pianist, it is logical to assume that the stronger the hand muscles, the more they can endure before fatigue and breakdown occur.

Past research on pianists' overuse injuries has suggested mainly hand intrinsic muscle involvement especially on the right side (Hochberg et al, 1983 ; Caldron et al, 1986 ; Fry, 1986a,c,1987 ; Dawson,1988 ; Revak,1989 ; Hartsell & Tata, 1991 ; Branfonbrener, 1991). The general intention of this study was to investigate some right hand characteristic factors that might be associated with the development of overuse injuries among piano students including : hand grip strength, hand pinch strength, hand stretch & span, hand grip endurance and hand pinch endurance.

The main purpose of this study was to determine if there were any differences in the right hand characteristic factors among the group with overuse injury and the group without overuse injury.

B. OBJECTIVES

The first objective of the study was to determine the prevalence of piano playing-related overuse injuries among piano students at the University of Alberta and the colleges in the Edmonton area.

The second objective was to determine whether the following factors were associated with overuse injury : (1) right hand grip strength, (2) right hand tip pinch strength, (3) right hand stretch & span, (4) right hand grip endurance, and, (5) right hand tip pinch endurance.

The third and final objective was to compare the group with overuse injury and those without injury on other factors which might be associated with overuse injury, such as (1) gender, (2) age, (3) years of piano playing, (4) length and frequency of piano practice, (5) the rest periods taken within each session, (6) involvement in sports activities or involvement in recreational activities, (7) general techniques or characteristics of playing including playing style and mechanics, and, (8) habit of practicing with the pain.

C. RESEARCH HYPOTHESIS

This study was an endeavor to test the hypothesis that piano students without overuse injuries had stronger right hand grip and tip pinch strength as well as better endurance and larger right hand stretch & span size than those with overuse injury.

In terms of the other factors measured, the study tested the hypothesis that piano students with overuse injury versus those without injury were :

1, More likely to be females.

2, Older in average age.

3, Played the piano for less years.

4, Frequently practiced for longer hours with little rest periods within each session.

5, Not as involved in sports and recreational activities.

6, Played with an awkward hand positioning & technique.

7, Practiced through the sessions with pain.

D. DEFINITIONS

The following words were defined as used in this study :

1, Legato Playing - bound together performance of music so that there is no perceptible seperation between notes. (Kennedy, 1980)

2, Middle C - the first note of the natural scale, located in about the middle of the piano.

3, Octave Playing - simultaneous playing of the thumb and fourth or fifth finger of one hand held rigidly apart.(Hochberg et al, 1983)

4, Trill Playing - playing with rapid alteration of two adjacent keys. (Hochberg et al, 1983)

5, Piano Pedagogy - the art or science of teaching piano playing.

6, Overuse Injury (Discomfort) - changes that were brought about in the muscle and joint ligaments from excessive use causing pain, loss of function and almost always demonstrable tenderness in the affected structures. (Fry, 1987) It was identified by the occurance of pain (alone or in combination with weakness, stiffness, tenderness or swelling) within the past 2 years that was related to playing the piano.

7, Tip Pinch - pinch between the tip of the thumb and the tip of each finger. (Mathiowetz et al, 1985a)

8, Flexibility - range of movement in a joint either due to a given external torque (passive flexibility) or due to the action of the muscles (active flexibility). (Wagner, 1974)

9, Hypermobility - a remarkably high degree of joint movement that can occur in the absence of other stigmata associated with connective tissue disorder. (Branfonbrener, 1990)

10, Muscle Strength - the amount of tension that a muscle or muscle group can exert in a single maximum contraction.

11, Muscle Endurance - the capacity of a muscle or muscle group to sustain a contraction for a certain period of time or to perform continuous work.

12, Rest Periods - the time in minutes taken by the pianist for a rest within each practice session.

13, Hand span - the measurement in centimeters of hand flexibility from the tip of the thumb to the tip of the little finger.

14, Hand Stretch - the active flexibility of the hand over the keyboard measured by the number of keys the hand span can cover.

15, Relative Endurance time - the time in seconds that the subject can hold 50 % of his or her maximum voluntary contraction.

16, Awkward Hand Position - rigid unphysiological positioning of the hands assumed by some pianist in spite of high degree of flexibility required in piano playing.

E. LIMITATIONS

This study presented with the following limitations :

(1) This study depended on the validity and reliability of the Jamar Dynamometer and pinch meter. Mathiowetz et al (1984) reported the validity and reliability of the Jamar Dynamometer and pinch meter.

TABLE I

VALIDITY AND RELIABILITY OF THE JAMAR DYNAMOMETER AND PINCH METER AS REPORTED BY MATHIOWETZ ET AL (1984)

	VALIDITY	RELIABILITY	
		INTER-TESTER	INTRA-TESTER
GRIP	+/- 3 %	0.97 & ABOVE	0.8 & ABOVE
PINCH	+/- 1 %	0.98 & ABOVE	0.8 & ABOVE

A pilot study done by the investigator on the Jamar dynamometer and the pinch meter had found the validity to be +/- 1.64% for the Jamar dynamometer and +/- 1.3% for the pinch meter when known calibration weights were suspended from the hand piece. The test-retest reliability were found to be 0.97 for the Jamar dynamometer and 0.80 for the pinch meter.

(2) Muscle strength at the elbow and shoulder joints was not reported in this study.

(3) Due to the character of this study, determining whether tip pinch and grip weakness of the hand was the precipitating factor or the result of the overuse problem, was limited. A question was therefore asked in the questionnare if the subject was experiencing discomfort at the moment of testing.

(4) Sample size restricted the number of predisposing factors that were studied.

G. DELIMITATIONS

The following delimitations applied to this study :

(1) The study dealt only with piano students at the post secondary level of education who were below age 35 years.

(2) Muscle strength measurements taken were only those of hand grip and tip pinch between the thumb and the lateral 4 fingers.

(3) Overuse discomfort was limited to symptoms experienced during or after playing the piano.

CHAPTER II

LITERATURE REVIEW

This chapter discussed the injuries encountered by instrumental musicians and more specifically, overuse injuries encountered by pianist.

I. GENERAL MEDICAL PROBLEMS ENCOUNTERED BY INSTRUMENTAL MUSICIANS

Instrumental musicians, like any other individuals are prone to medical problems. At times, even the common cold has a devastating effect for a vocalist and a dry throat or cough will greatly affect wind players. Some musicians, due to their deep devotion to their art, practice constantly having no time for physical exercise or recreation. Due to the loss of body conditioning by doing this, they were at times predisposed to injuries (Poore, 1887).

Injuries also happen while doing other activities such as housework or sports. If these activities affect the hand needed to play the instrument, this could mean a period of unemployment.

In 1982, Harman compiled a classification of problems encountered by musicians. She divided the problems into 6 basic categories : Dermatitis, Nerve Compression Syndrome, Occupational Cramps, Intraoral Pressure Problems, Cardiac Abnormalities, and Miscellaneous. Later, a survey done on 48 member orchestras of the International Conference of Symphony and Opera Musicians (ICSOM) in 1988 by Fisbein et al listed 24 different non-musculoskeletal conditions (Appendix A). This ICSOM survey included the biggest sample size by far. Out of 4025 questionnaires distributed, 2212 responded (55%). In this study, 61% of ICSOM musicians reported that they took part in regular physical exercise. However, 82% of the ICSOM musicians reported experiencing a medical problem and furthermore, 76% listed at least one problem as severe in terms of its effect on their musical performance (Fishbein et al,1988).

A. CLASSES OF PERFORMANCE RELATED PROBLEMS FOR INSTRUMENTAL MUSICIANS

More recently, studies, done by doctors in music medicine clinics, have divided performance related problems into 3 general classes for instrumentalists, which are : (1) Focal Dystonias, (2) Nerve Entrapment Syndromes and (3) Musculoskeletal Overuse Injuries (Hochberg et al, 1983 ; Knishkowy, 1986 ; Hoppman & Patrone, 1989; Branfonbrener, 1991).

A 1. FOCAL DYSTONIA

A variety of names have been given to denote the motor dysfunctions suffered by musicians when faced with playing the instrument. These names include idiopathic dystonia, occupational cramps or focal movement disorder (Hoppman &

Patrone, 1989). Hochberg (1990) stated that 25% of the musicians seen in their clinic presented with focal dystonia. Initial symptoms of focal dystonia were ascribed to stress, tension, cramping or "battle fatigue" of a performer. However, all these symptoms became sources of painless frustration when the instrument was played, being characterized by abnormal, involuntary movements and postures caused by muscle spasms.

A few features specific for different musical instruments have been described. These involved pianists with the right fourth and fifth finger flexion, guitarists with right third finger flexion, wind players with right second finger flexion, violinists with left first & second finger flexion and right thumb & wrist flexion (Hoppman & Patrone, 1989 ; Hochberg, 1990).

A 2. NERVE ENTRAPMENT SYNDROME

Nerve entrapment is generally referred to as nerve compression at specific vulnerable sites. The entrapment has been a frequent cause of symptoms suffered by musicians due to long hours of practice, repetitive motions, and especially unusual positions. Among the clinical findings, pain, (which may occur at rest or during activity usually radiating beyond the area of entrapment) paresthesia, numbness, tingling, burning, coldness, and even itching have been reported. Physical signs including weakness and skin temperature changes have also been reported (Lederman, 1986).

The usual syndromes encountered by instrumental musicians included digital neuropathies, carpal tunnel syndrome, pronator syndrome, thoracic outlet syndrome, and cervical radiculopathies. The ulnar nerve may also be involved either due to compression at the Canal of Guyon, or at the elbow giving rise to the cubital tunnel syndrome. Lower extremity saphenous nerve compression, although rare, had also been reported.

Knishkowy (1986) studied 52 musicians and reported 36% suffered from peripheral nerve disorders. Among the musicians, Knishkowy found the right upper extremity was more commonly affected for pianist and the left for string players. Hoppman & Patrone (1989) stated that median nerve entrapment was the most common entrapment syndrome seen among instrumental musicians. This median nerve entrapment occurred most often at the wrist, which gave rise to the carpal tunnel syndrome.

A 3. MUSCULOSKELETAL OVERUSE INJURIES

Knishkowy (1986) revealed that most of the instrumental musicians studied (51%) suffered from overuse injuries. As with other studies done using instrumental musicians as subjects, the most common injuries were classified as "musculoskeletal overuse injuries" (Hochberg et al, 1983 ; Caldron et al, 1986 ; Dawson, 1988 ; Lockwood,1988 ; Manchester, 1988 ; Nolan, 1989 ; Revak, 1989; Hartsell & Tata, 1991).

Past research has shown that the common locations involved with overuse injuries include : the forearm, the wrist, the hand (Knishkowy, 1986) the fingers, the shoulders, and the back (Caldron et al, 1986). Dawson (1988) stated that more intrinsic than extrinsic muscle strain problems occurred, and that the forearm or wrist muscle strains were primarily in the extensor group. The upper extremity, which is used most repetitively, has been reported as the most frequent site of involvement (Hoppman & Patrone, 1989 ; Branfonbrener, 1991). Hartsell & Tata (1991) reported that their subjects blamed the development of overuse injuries on the practice of the primary instrument (93.8%) and not the practice of the secondary instrument. They also stated that the repetitive and skilfull practice of the musical instrument requiring control and coordination led to overuse injuries. Futhermore, this study (Hartsell & Tata, 1991) supported the claim by Caldron et al (1986) that inexperience at a given task was not a risk factor in the development of overuse injuries. However, physiologically proper technique should be followed for this to hold true as Revak (1989) quoted Polnauer & Marks (1967) saying that "a physiologically inefficient player tends to overexert himself, fatigue more readily and (be) more prone to develop an occupational disease than a player whose technique is based on more sound physiological principles" (p.150).

II. THE PIANIST AND OVERUSE INJURIES

The earliest written account of injuries among musicians was by Poore in 1887. He described a group of female pianists who presented with nerve-tenderness accompanied by (a) muscular-disability, (b) more or less tremor, (c) pain or early fatigue, and, (d) limb discomfort which was worse at night. Poore suggested that these injuries were due to overuse when playing the piano because in those days, pianists followed a strict hand positioning technique, the "Stuttgart Method" (p.442), practiced long hours and compounded their own condition by poor physical health, especially for the females. He further stated that rest was the best treatment. However, as it was true then and now, at the first sign of relief, the pianist flies straight back to the keyboard thereby not allowing sufficient time for the tissues to properly heal.

A. AREAS OF AFFECTATION AND CLINICAL FINDINGS

More specifically than for other instrumental musicians, previous research has reported that the right hand was most commonly involved for pianists with the highest frequency seen in the fourth and fifth fingers (Hochberg et al, 1983 ; Revak, 1989 ; Branfonbrener, 1991 ; Hartsell & Tata, 1991). A study on the incidence of upper extremity discomfort among piano students reported 49% of the discomfort to be in the hand, right more than left. The ring finger (12%) followed by the little finger (9%) were the most common sites (Revak, 1989).

Overuse injuries reported were inflammatory or non-inflammatory (Dawson, 1988). Clinical findings of overuse injuries among pianists ranged from just pain or aching without any inflammatory process to as severe as stiffness, swelling, or even curling of the fingers. (Appendix B) Pain was the most common complaint reported without any accompanying signs (Hochberg et al, 1983 ; Lederman, 1986 ; Fry & Rowley, 1989).

Pianists usually complained of discomfort that lead to loss of control, decreased facility, endurance, speed, strength and lack of tension (Hochberg et al , 1983). Bard et al (1984) evaluated hand radiographs of 20 pianists with a mean age of 33.9 years (range 22 to 76 years). At the time of their survey, only one 28 year old female complained of pain. However, all the subjects at some time, developed symptoms of fatigue or pain. Their evaluation revealed alignment adaptative changes in all 20 pianists. These changes consisted of radial rotation of the 5th , 4th & 3rd metacarpals with associated phalangeal rotation of the 5th digit in 19 pianists. Degenerative changes were also seen, characterized by joint space narrowing of the metacarpo-phalangeal (MCP) joint of the 4th, 3rd & 5th fingers; osteophyte formation in the MCP joint of the 2nd, 3rd & 5th fingers; and finally, mechanical remodelling that included periosteal thickening of the ulnar side of the metacarpals and proximal phalanges especially on the 5th digit together with flattening of the phalangeal tufts characterized by loss of trabecular lacework and sclerosis.

B. PREDISPOSING FACTORS THAT LEAD TO OVERUSE INJURIES AMONG PIANIST.

Factors predisposing to the development of overuse injuries may be grouped as intrinsic or extrinsic. The former are comprised of body size, muscle strength, muscle tone, flexibility, and the presence of underlying musculoskeletal disease. The extrinsic factors that predispose to overuse injuries relate to a musicians' technique and playing environment. The pianist's hand position and posture, practice schedule, and intensity of practice all contribute as extrinsic factors to the development of overuse injuries.

B 1. EXTRINSIC FACTORS

B 1 a. THE INSTRUMENT

The pianoforte is a keyboard music instrument that was originally invented by Bartolomeo Cristofori in 1709. This instrument has had its share of modifications with time. The present day piano as we know it emerged between 1825 and 1900 from lighter harpsichords and pianofortes. Fry (1986d) compared the early 19th century piano with the modern Steinway grand piano. He stated that the early piano involved about 6 millimeters of key travel, requiring about 23 grams to depress each key and a middle C string tension of about 12 to 15 kilograms. The arrival of the iron-frame technology by the end of the 19th century brought with it a change in the piano manufacturing industry. A single cast-iron frame piano allowed up to 80 kilograms tension in the middle C string, required about 45 grams to depress each key and a distance of 9 millimeters for key travel. The present day Steinway concert grand piano involves about 10.5 millimeters for key travel, 90 kilograms of middle C string tension and requires about 50 to 60 grams of depression pressure for each key (Fry, 1986d).

Not only was there a change in the structure of the piano, but the concert halls also grew larger with time, thereby requiring more work from the pianist to project the sound.

B 1 b. DIFFERENT HAND POSITIONS AND TECHNIQUES

Piano pedagogy has been handed down from generation to generation. Some schools-of-thought have received modifications but some teachers still advocate certain styles of playing which are deemed unanatomical both for early pianos and especially for the modern piano. An example was cited by Harman in 1991 referring to the "finger school" method which emphasized the use of the fingers only and extensive technical practice which worked well for the early light harpsichords but not for the modern pianos.

The old notion that pianist should stay with a fixed hand position has slowly been repudiated by piano teachers and it is now believed that the position of the hand depends on the music being played, and on the hand characteristics of the pianist. The natural movements and consequently the most suitable momentary hand position should be sought. (Gat, 1958)

There have been numerous hand postures used by different pianists, but basically, two hand positions have been commonly seen in piano playing depending on the musical tone to be achieved. The first was with a fairly flat hand having the wrist, the MCP joints, and the interphalangeal (IP) joints in neutral. The other position involves the MCP and the proximal interphalangeal (PIP) joints flexed with slight wrist extension. The second posture resembled a more circular or curve finger position. The former, with the MCP joints extended, more MCP abduction-adduction was possible. Less MCP flexion-extension was needed for the fingers to depress the piano keys. The curve finger position allowed more rotation in the MCP joints but less abduction-adduction, therefore more wrist radial and ulnar deviation were required when playing (Bejjani et al, 1989).

The straight hand playing position is more commonly used for playing legato music where notes are smooth, even and unbroken because the fingers serve as elongations of the keys. In this position, small movements of the muscles bring about larger movement of the finger ends, thus muscle activity is less tiring which is more advantageous for low volume - high velocity music. Notes requiring a more forceful action are usually done with a curve finger position as greater muscle activity is required for small movements, thereby control and domination of the fingers are easier in this position (Gat, 1958).

Bejjani et al (1989) analyzed 3 different positions in playing 3 different tasks (Octaves, Trills & Legato) at the piano. They found that a flat hand & finger position showed an increased deltoid muscle activity in octave playing, and the flexor carpi radialis muscle showed the least activity in the flat hand position when playing octaves, trills or legato. These investigators also found that the 3rd finger's distal interphalangeal joint (DIP) and MCP in this position moved the least in flexion-extension when playing all three tasks. The curved position showed increased deltoid activity in legato playing. They further stated that in a curved finger position, the intrinsic muscles were acting as torsional stabilizers and shock absorbers of the entire finger (Bejjani et al, 1989).

Harding et al (1989) demonstrated less DIP joint reaction force with a straight finger position than a flexed position.

The characteristics of the hand also influenced the posture assumed by a pianist. The relative length of the thumb is the most important factor in forming the hand position. A short thumb usually forces the pianist to have a curved finger position and thus the back of the hand assumes a more steeped position with a more dorsiflexed wrist. Also, the length of the fingers makes a difference, a stretched position being suited for shorter fingers in high velocity playing. The difference between each finger length also influences the hand position assumed. Fairly similar finger length would mean easier equalization of their striking power as the differences in length do not have to be compensated by a stronger bending of one of the fingers (Gat, 1958).

The position of the hand influences which group of muscles are primarily used. Schultz in 1949 was in favor of the flat hand position as this position worked primarily the intrinsic muscles of the hand (lumbricals). As the lumbricals flex the MCP joints, the key is depressed. The recoil of the piano keys pushes the fingers back to the resting position (Gat, 1985 ; Fine, 1987 ; Adlam, 1981; Slonimsky, 1989). With the bent position, the long flexors are used, yet the long extensors are also called upon to act as fixators of the wrist and hand in a dorsiflexed position. There were others who preferred positions that mainly use the extrinsic musculature. A recent study by Tubiana et al (1989) reported on the ideal position to be assumed by pianist that would give minimum stress and minimal energy expenditure. They stated that :

> "the forearm in partial pronation, with its transverse axis above the wrist forming an angle of approximately 30 degrees with the keyboard. The hand itself is in complete pronation,thus creating a volar arch that increases the force in the fingers and allows maximum contact of the pulps of the fingers with the keys. The axes of the hand and forearm form an angle of 15 degrees to the ulnar side with the wrist in slight extension. This position allows more efficient finger flexion as it puts the extrinsic tendons in the ideal physiologic axis." (Tubiana et al, 1989 p.74)

Finger extensors actively lifting the finger after depressing the key are not commonly needed; as stated before, they act mainly as fixators. Piano keys have a characteristic recoil that helps lift the keys back up. The main muscles needed are the extrinsic flexors and the intrinsics which flex and abduct or adduct the fingers. Also, radial and especially ulnar deviators are at work along with other muscles in the forearm, such as the pronators and supinators, as well as muscles in the shoulder, such as the deltoid and rotator cuff.

Some authors believed that the hand position on the keyboard hangs and maintains the forearm, and so the extensors are not needed. Hmelnitsky & Nettheim (1987) believed that pushing 1 key down would automatically lift the other fingers due to the action of the flexors (Weight-Playing method). With this method, pianists tended to put too much effort into the work. The musical tone is produced with halfway depression of the key, so that "bottoming out" usually makes the pianist waste energy (Gat, 1958 ; Kochevitsky, 1967 ; Last, 1980).

The techniques mentioned thus far were the "finger school" method using just the fingers, and the "weight playing" method (Hmelnitsky & Nettheim, 1987) using the weight of the whole arm to play the piano. In analyzing the different schools-of-thought in piano pedagogy, Kochevitsky (1967) stated that aside from the old finger school, there developed anatomical-physiological techniques in the mid-19th century in which the teachers went against the traditional belief of technical finger practice. This school-of-thought emphasized the proper physiological positioning and focused on free and relaxed techniques. Lately, the "psycho-technical school" believing in the importance of using the "mind" has developed, again focusing on freedom of techniques but emphasizing "feeling the music".

It is common to see pianists trained in a mixture of the different schools-of-thought. But regardless of the methods, the most commonly used technique, using a free natural movement of the fingers, arms and trunk seems to be the method that is the most sound in order to stay away from injuries. (Last, 1980) This mechanism involves playing with each finger working from the knuckle at its base, the hand from the wrist, the forearm from the elbow, the upper arm from the shoulder and to the point where the trunk moves from the hips as one goes up and down along the keyboard. (Newman, 1974)

However, it is unfortunate that until now, there still exist strong advocates of the finger school method even with the recognition of injuries stemming from awkward piano playing. Also, there are beginners, who, at times, tend to use awkward techniques or too much force, which may overwork the muscles leading to injuries (Revak, 1989).

B 1 c. TIME AND INTENSITY OF PRACTICE

Fry and Rowley (1989) compared two British secondary schools for the prevalence of upper limb pain among specialist music students (age range : 7 to 19 years). They found that the prevalence was significantly higher in the music school than in the regular school (71% vs. 50%) and suggested that the intensity of practice rather than just the actual hours spent practicing was the critical factor in the development of overuse injuries. Lockwood (1988) studied secondary school aged musicians (10-18 years old) and showed that long hours of practice (19 +/- 7.6 hours per week) did have an effect on the development of instrument related problems.

Newmark and Lederman (1987) studied chamber music conference participants and stated that the sudden increase in the amount of practice led to the development of injuries among musicians (72%) and concluded that "rapid increase in practice time, especially superimposed upon a baseline of relatively little routine practice, predisposes a musician to overuse injuries" (p.144).

B 1 d. EXPERIENCE / STUDENTSHIP

Past research has shown that not only do professional musicians suffer from musculoskeletal overuse injuries, but the majority of the musicians that seek medical help are students (Caldron et al, 1986 ; Fry, 1986a & 1987 ; Lockwood, 1988 ; Manchester, 1988 ; Fry & Rowley, 1989 ; Hartsell & Tata, 1991).

Students are faced with additional pressures from having to attend classes, at the same time as having to practice regularly, and facing juries and examinations that determine their future in the art. (Hartsell & Tata, 1991). At times, because of all these pressures, recreation and physical activities are neglected.

Hartsell & Tata (1991) studied the factors that were related to the development of overuse problems among music students at the University of Western Ontario. They confirmed previous research that the effect of long hours of practice together with the greater demands placed on students to excel contributed to a high prevalence rate of overuse injuries. Their findings supported previous investigations by Fry identifying the overuse syndrome as the nemesis of the musician, whether performer or student.

B 2. INTRINSIC FACTORS

B 2 a. GENDER

From past research, overuse injuries always seem to be more prevalent among female than male musicians (Caldron et al, 1986; Fry, 1987 ; Fishbein et al, 1988 ; Lockwood, 1988 ; Manchester, 1988 ; Goodman, 1989 ; Revak, 1989). Caldron et al (1986) stated that females were more likely to report injuries and seek medical care than males.

However, Fry (1986a & c) in a study on orchestra members and students showed that because of the difference in the distribution of males and females, females were predominant among students and males among performers to report injuries.

B 2 b. FLEXIBILITY

Hand and finger flexibility plays a role with respect to aptitude, for activities in which individual fingers perform defined movements independent of each other. Playing musical instruments, particularly the keyboard and string instruments has been where flexibility played an important role.(Wagner, 1974)

Not only is the reach important for playing the keyboard (octave playing), but hand size and shape also play a role. Indeed it is practical to assume that an individual with a bigger hand or greater hand span would be more at ease if the musical piece required a span of an octave or more apart. Past research seemed to confirm this hypothesis, and Wagner (1988) even suggested that lack of flexibility would lead to injury. Ortmann, in his 1929 study, also projected the idea of finger flexibility as a factor in determining the proficiency of a pianist. Historical records further substantiated this hypothesis : legendary musical figures such as Paganini, Lizst, and Rachmaninov, are all reported to have had hypermobile joints (Smith, 1982). Furthermore, Henson & Urich (1978) reported that the great musician, Robert Schumann, who, because of his hand injury with resultant decreased flexibility, had to concentrate on composition rather than on performance.

Recent research has shown that hypermobility of joints is a common feature found among musicians (Smith 1982 ; Bejjani, 1984a ; Larsson et al, 1987 ; Branfonbrener 1990) with females more than males (Larsson et al, 1987 ; Wagner, 1988 ; Lee, 1990). With hypermobility, there are additional risk and problems involved. Branfonbrener (1991) stated that with hypermobile joints, muscles have to work harder to maintain stability and might lead to overuse injuries. Furthermore, Nolan (1989) reported that the mechanical forces which control the range of motion and stability possessed by the thumb's 3 joint system (trapezial-metacarpal, metacarpo-phalangeal & the interphalangeal joints) would be severely altered by hypermobility and could result in thumb problems for pianist.

Other studies on the effects of hypermobility describe : traumatic synovitis due to joint laxity in a guitarist (Bird, 1979); benign hypermobility leading to technical difficulty and discomfort in a flutist (Patrone et al, 1988); and joint hypermobility leading to neuropathies (Francis,1987 ; March, 1988).

B 2 c. UPPER EXTREMITY STRENGTH AND THE PIANIST

In studying the prevalence and incidence of overuse injuries among instrumentalists, it has been questioned whether or not inherent muscle strength was one of the protective mechanisms against the development of injuries. Manchester (1988) suggested that men's greater upper body strength may lend some protection against overuse syndrome. He suggested that women could lower their risk by doing upper body exercises. Both Lederman (1986) and Hartsell & Tata (1991) suggested properly supervised strengthening exercises for the treatment and prevention of overuse injuries. However, in Revak's (1989) study, technical training to strengthen the muscles of the hands was reported as one of the predisposing factors that led to the development of overuse injuries. Futhermore, Fry (1986) has suggested that strengthening exercises only increase the symptoms.

A study by Philipson et al (1990) examined the muscular activity determined by electromyography in 9 violinists. Their study on the trapezius, deltoids, biceps, and triceps muscles revealed that the muscular electrical activity levels were higher for the trapezius, right deltoid and right biceps among violinists who complained of neck and shoulder problems. They concluded that violinists with neck and shoulder pain used, in some muscles, significantly more muscle force for the task than those without pain.

Grieco et al (1989) studied the muscular efforts of 3 male and 3 female piano students using electromyography. They studied 8 groups of muscles, namely : right upper trapezius, right deltoid, right biceps, right forearm extensor muscles, right forearm flexor muscles, right lumbar erectors, first dorsal interosseus of the right hand and left upper trapezius. Thirty-eight percent of their subjects were without complaints, however, 62% had from 1 to 5 musculoskeletal complaints. Of these, the most frequent were spinal disorders and a painful wrist and forearm. Their results showed that the deltoid and biceps had a low effort level as measured by electromyography. The lumbar erector, bilateral trapzius and the right forearm flexor muscles had higher, though acceptable effort levels. They also found that females had higher left trapezius activity and males have higher forearm flexor muscle activity. Another difference between males and females is the first dorsal interosseus muscle of the females which revealed excessive static and median loading as measured by electromyography. However, forearm extensor muscles were homogenous among both genders showing excessive static and median loading. More importantly, these authors suggested that the smaller build and the lower muscle power of the females demanded greater effort of the large muscles of the shoulder and trunk to sustain the finger movement.

To date, not much research has been done concerning the upper extremity strength of musicians. Bejjani et al (1984) reported their study which measured muscle strength variables in 71 professional musicians and a control group of non-musicians. They were trying to determine if the earlier musicians started playing, whether they were better adapted to their instruments. They demonstrated that the upper extremity strength were symmetrical for violinists when tested by grip and pinch strength. However, for pianists, their data showed right grip and pinch strength not being correlated and bilateral pinch to be different. Their study did not look into the role of strength in the prevalence or incidence of injuries. A more recent study by Johnson (1990) was presented to the 1989 Hand Therapist annual meeting. The study was to establish clinical norms of grip strength, lateral pinch and palmar pinch for professional instrumentalists. The device used was a Jamar Dynamometer and pinch meter. Unfortunately, the details of the study were not published.

So far, the literature is still limited especially in the area looking into the occurance of overuse injuries among pianists.

III. SUMMARY

Research in the field of music medicine has shown that musicians, especially pianists (40-60%) presented to the music clinics with overuse injuries (Branfonbrener 1991). The majority of the complaints involved the hand musculature followed by the back and the shoulder. Multiple factors have been identified that predispose pianists to the development of overuse injury from inherent hypermobility, to techniques and practice habits being followed. A few physicians have raised the question about the role of strength in this occupational disorder, however, few studies have been done and none directly on the role of hand strength have been reported.

CHAPTER III

Methods

I. THE PILOT STUDY

Twenty first year physical therapy students at the University of Alberta were recruited to examine the test-retest reliability of the Jamar dynamometer and the pinch meter. The volunteers were asked to exert their maximum effort for both strength testing instruments and the peak score in pounds was recorded. Test-retest reliability was found to be significant with a correlation of 0.97 for the Jamar dynamometer and 0.80 for the pinch meter tested a day apart. Validity of the instruments were tested with known calibration weights suspended from the hand piece and showed +/- 1.64% for the Jamar dynamometer and +/-1.3% for the pinch meter.

II. THE STUDY

A. STUDY DESIGN

The research project was a cross-sectional study in which the prevalence of musculoskeletal overuse injuries among piano music students was determined by having the subjects answer to a questionnaire based interview. The right hand muscle strength and endurance of the volunteers were measured by the primary investigator during the same session. The study took no more than an hour and a half of the volunteer's time.

B. STUDY PARTICIPANTS

Subjects were volunteer music students who play the piano as their primary or secondary instrument. Students were recruited from the Department of Music, Faculty of Arts at the University of Alberta. Students from Grant McEwen College, Concordia College, King's College and the North American Baptist College majoring in piano were also recruited. Students taking post-secondary education and majoring in music, either for performance or for teaching, ensured that the subjects had been playing the instrument for more than 2 years. Also, being post-secondary students, they would have been compelled to practice more at times when examinations or performances happened throughout the school year. Past research has reported occurrence of problems after 2 to 5 years of playing and were precipitated by a change in repertoire or any increase in time or intensity of practice (Fry, 1987). Being in post-secondary education, they had occassion to change or upgrade their repertoire. From past research, it was expected that 49% to 51% of the students had overuse injury (Revak,1989 ; Knishkowy,1986).

All students in the Department of Music who played the piano as their primary or secondary instrument were invited to participate in the study. The Department had stated that piano major students numbered about 30 and an additional 3 students were taking piano as a secondary instrument. Past research has shown a 30-50% response rate. (Revak 1989; Caldron 1986;

Goodman 1989). The students in the music department of colleges in the Edmonton area including : Grant McEwen College (41 students), Concordia College (15 students), King's College (5 students) and the North American Baptist College (13 students) were also recruited .

Sample size calculation had been done with 5 independent variables and 1 dependent variable. With an alpha of 0.05 and a beta of 0.20, the formula $[\ n = L /(f)2 + k + 1\ ]$ where $(f)2$ was $(R)2 / 1-(R)2$; k was the number of variables and $(R)2$ was the variance to be declared significant which was 0.20 was used (Cohen & Cohen, 1983).

$$\begin{aligned} n &= L / (f)2 + k + 1 \\ &= 13.62 / .25 + 5 + 1 \\ &= 54.48 + 5 + 1 \\ &= 60.48 \text{ or } 60 \end{aligned} \qquad \begin{aligned} (f)2 &= (R)2 / 1-(R)2 \\ &= .20 / 1-.20 \\ &= .20 / .80 \\ &= .25 \end{aligned}$$

A letter of support had been provided by the chair of the Department of Music. (Appendix C)

Recruited volunteers satisfied one more criteria to be included in the study :

The subjects should be no older than 35 years of age.

Males and females were further divided into different subgroups as it has been shown that males are stronger than females by past investigations (Schmidt & Toews, 1970 ; Mathiowetz et al, 1985a ; Petersen et al, 1989).

C. DATA COLLECTION

A letter introducing the purpose of the study and briefly describing the method of measurement and time required from the volunteer was distributed to all piano students in the Department of Music at the University of Alberta, Grant MacEwen Community College, Concordia College, The King's College and the North American Baptist College. (Appendix D) A list of piano instructors was requested from the Department office of each institution and these individuals were approached by the investigator to enlist their support for recruiting their students. A mutually convenient time was arranged for the volunteer and the primary investigator to take the measurements and fill out the questionnaire. The length of time for the whole session was no more than 1 1/2 hours.

The occurrence of overuse injury was determined by the presence of pain or discomfort related to piano playing within the past two years with or without accompanying clinical findings such as fatigue, pins and needles, tightness, swelling, redness, stiffness, weakness, cramping, loss of control and curling of the fingers as reported by the subject. Previous studies have shown that pain was the main, and at times, only complaint seen in overuse injuries among musicians (Hochberg et al, 1983 ; Fry, 1986a ; Manchester, 1988 ; Mandel, 1990). The information of overuse injury was taken from the questionnaire which was answered by the subject on the day of the measurement.

Past research into music medicine has led to the development of a few survey questionnaires to determine the extent of injuries among musicians. Only the one used at the Massachusetts General Hospital was published in detail (Silverman, 1983 ; Hochberg, 1990). In determining the prevalence of overuse injuries, the questionnaire by Hochberg used at the Massachusetts General Hospital was adapted due to its thoroughness in asking relevant questions concerning musical overuse injuries. (Appendix F) However, some parts such as glove size, titles of exercises, favorite repertoires, surgical procedures & therapy taken and concert tour information were deleted. Other pertinent questions such as level of education, recreational activities, years of piano playing, and other demographic questions were added to be more relevant to the situation faced specifically by post secondary piano music students. (Appendix F)

The questionnaire served three purposes in this study. The first purpose was to identify subjects with overuse injury and describe its accompanying signs and symptoms. The second was to classify subjects on one of the hand characteristic factors : the hand stretch over the keyboard. Finally, the remaining questions were used to describe the overuse and the non-overuse injury groups according to gender, age, physical activities, level of education, years of piano playing, playing style, playing mechanics and playing habits.

The other variables, the hand muscle strength and endurance of the right hand were measured using the Jamar Dynamometer and the Pinch meter. The Jamar dynamometer has been the instrument recommended as the best measure of grip strength. (Mathiowetz et al, 1984) It was the instrument recommended by the American Society of Hand Therapists for grip strength measurement (Fess & Moran , 1981).

Mathiowetz et al (1984) tested the validity and reliability of the Jamar dynamometer and the pinch meter. They found the former to be accurate to +/- 3% for validity and the pinch meter to be +/- 1% for validity when known weights were suspended from the hand piece. Inter-rater reliability for both the right and left hands demonstrated a significant correlation of at least 0.97. Finally, test-retest reliability done a week or less apart, using a mean of three trials showed at least a 0.8 correlation coefficient. In the pilot study done by the investigator, the validity (+/- 1.64% for the Jamar and +/- 1.3% for the pinch meter) and reliability (0.97 for the Jamar and 0.8 for the pinch meter) were found to be the same as the ones reported by Mathiowetz et al. Fess (1987) found that the Jamar dynamometer as highly reliable with correlation coefficients for calibration to be 0.9994 and above.

Grip strength of the subjects was determined by having each subject hold the dynamometer according to the recommended positions of the American Society of Hand Therapists (1981) : "The patient should be seated with his shoulder adducted and neutrally rotated, elbow flexed at 90 degrees and the forearm and wrist in neutral position" (p.6). The second handle position of the dynamometer from the bottom up was used in evaluating grip strength as recommended by the Society. The mean of 3 trials was taken to represent the maximum strength of the subject and a rest period of 3-5 minutes was given between each trial as this rest period has been found to take care of the fatigue factor (Fess & Moran, 1981).

The literature has identified 3 types of pinch usually assessed : (1) prehension of the thumb pulp to the lateral aspects of the index finger (key, lateral, Pulp to side Pinch); (2) pulp of the thumb to the pulps of the index and long fingers (three jaw chuck, three point chuck) and (3) thumb tip to the tip of the index finger (tip-to-tip) (Fess, 1990). In this study, the tip pinch strength of the index, middle, ring and little fingers with the thumb were taken with the same number of trials (3) and length of rest period (3 to 5 min.) as for the grip strength test (Fess & Moran, 1981). Tip pinch of the fingers was used because it tested the individual finger pad which was closest to the motion used in piano playing and still stayed within the accepted classical method of testing finger strength.

Muscle endurance for both the grip and tip pinch were also measured using the same instruments. The subjects were asked to give 50% of their maximum effort and the time they could maintain the effort level was taken in seconds (Relative Endurance Score) (Heyward, 1975 ; Williams et al, 1987 ; Bystrom & Kilbom, 1990).

D. STATISTICAL ANALYSIS

In determining the prevalence of musculoskeletal overuse injuries among the piano music students at the University of Alberta and each individual college, the number of cases identified over the total number of cases interviewed was calculated.

In achieving the second objective, logistic regression analysis was used to determine whether the independent variables of right grip strength, right tip pinch strength, right hand stretch and span, right hand grip endurance and right hand tip pinch endurance were associated with overuse injury. Logistic regression gave the risk ratio needed to achieve this objective and a chi square calculation for the significance.

Appropriate descriptive and inferential statistics were used to compare groups on other factors measured.

CHAPTER IV

RESULTS

SAMPLE INFORMATION

At the completion of data collection, 62 (57.94%) subjects responded out of a total sample pool of 107 subjects from 5 post-secondary institutions in the Edmonton area. (TABLE 1)

TABLE 1

VOLUNTEERS FROM 5 DIFFERENT INSTITUTIONS

	SAMPLE POOL	VOLUNTEERS
CONCORDIA COLLEGE	15	2 (13.3%) (1 M , 1 F)
GRANT MACEWEN COMMUNITY COLLEGE	41 (23 M , 18 F)	34 (82.9%) 19 M , 15 F (82.6%) (83.3%)
THE KING'S COLLEGE	5 (3 M , 2 F)	3 (60%) ALL M
NORTH AMERICAN BAPTIST COLLEGE	13 (ALL F)	13 (100%)
UNIVERSITY OF ALBERTA	33	10 (30.3%) 3 M , 7 F
TOTAL	107	62 (57.94%) 26 M , 36 F

Response rate ranges from 13.3% in one institution to as high as 100% in another. Data from 3 volunteers were not included in the analysis due to violation of the age criterion. These 3 subjects were all over the age limit of 35 years. Another 5 subjects were also excluded from the final analysis due to clinical manifestations presenting only to the left hand. A total of 54 cases were analyzed (Appendix G). Out of the 54 subjects, 24 (44.4%) were males and 30 (55.6%) were females.

OVERALL PREVALENCE

The 59 volunteer students were classified into overuse and non-overuse groups. Of the 59 cases, 5 (8.47%) had overuse injuries isolated to the left hand (1 M, 4 F), 8 (13.55%) had overuse injuries only to the right hand (3 M, 5 F), 21 (35.59%) presented with bilateral hand involvement (11 M, 10 F) and 25 (42.37%) have no clinical manifestation of overuse (10 M , 15 F).

In accordance with the objectives of this research project, only 54 cases were analyzed, the data from the 5 cases with only left hand involvement were excluded from the final analysis. Out of the 54 cases, 25 (46.30%) were classified as non-overuse and 29 (53.70%) were classified as overuse.

CHARACTERISTIC FEATURES OF THE VOLUNTEER STUDENTS

The features of the group with overuse injury were compared with the group without injury. Some demographic features including hand dominance, other instruments played, perceived physical condition, history of arm or hand injury and location of the present injury are given in Table 2.

TABLE 2

CHARACTERISTIC FEATURES BETWEEN OVERUSED AND NON-OVERUSED GROUPS

	OVERUSE GROUP	NON-OVERUSE GROUP
RIGHT HAND DOMINANT	93.1%	84.0%
PLAYING OTHER INSTRUMENT	58.6%	56.0%
PERCEIVED PHYSICAL CONDITION	FIT - 20.7% AVERAGE - 79.3%	FIT - 28.0% AVERAGE - 68.0% POOR - 4.0%
PAST INJURY	41.4%	12%
LOCATION	RIGHT - 27.6% BILATERAL - 72.4%	NEITHER - 100.0%

The majority of the volunteers were right hand dominant. Approximately half of the surveyed subjects played some other instrument. The majority of them perceived themselves as being physically average, however close to half of the overuse group had a history of past injury to the arm or hand. No tests were performed to determine actual physical fitness level.

The overuse group was evaluated according to the clinical manifestation reported to have been experienced. Table 3 shows the different signs and symptoms and other activities that precipitated the occurance of the signs and symptoms.

The majority of subjects experienced some kind of pain which at times occurred in isolation from other signs and symptoms. Stiffness was the next most common discomfort reported followed by fatigue, weakness and tightness occurring together with pain. The most common activity that brought out the signs and symptoms associated with piano playing was reported to be writing.

TABLE 3

CLINICAL MANIFESTATIONS OF THE OVERUSE GROUP

SIGNS AND SYMPTOMS	
PAIN = 82.8%	WEAKNESS = 44.8%
FATIGUE = 44.8%	TIGHTNESS = 44.8%
SWELLING = 34.5%	CRAMPS = 34.5%
REDNESS = 3.4%	LOSS OF CONTROL = 24.1%
STIFFNESS = 58.6%	DROOPING = 6.9%
PINS AND NEEDLES = 17.2%	OTHERS = 6.9%
THE ABOVE SIGNS AND SYMPTOMS WERE ALSO PRESENT WHEN :	
TYPING = 13.8%	USING EATING UTENSILS = 3.4%
LIFTING = 34.5%	SHAKING HANDS = 10.3%
TOOTH BRUSHING = 10.3%	OTHERS = 31.0%
WRITING = 48.3%	

OVERUSE INJURY AND RIGHT HAND CHARACTERISTICS

Pursuant to the second objective, the right hand characteristics comprising of hand grip & tip pinch strength, hand stretch & span, and the hand grip & tip pinch endurance were analyzed.

The mean values and standard deviations for the right hand characteristics of male subjects including the hand stretch over the keyboard are given in table 4 for both the overuse and non-overuse groups.

TABLE 4

RIGHT HAND CHARACTERISTICS FOR MALES

	MALE OVERUSE GROUP		MALE NON-OVERUSED GROUP	
	MEAN	STD.DEV.	MEAN	STD.DEV.
HAND STRETCH	9.28 keys	0.611	10.20 keys	0.919
HAND SPAN	22.17 cm.	1.008	23.02 cm.	1.44
GRIP STRENGTH	117.37 lbs.	19.21	109.03 lbs.	17.60
PINCH STRENGTH				
2ND F/T	17.20 lbs.	4.84	14.77 lbs.	3.05
3RD F/T	16.27 lbs.	4.40	15.74 lbs.	4.69
4TH F/T	10.99 lbs.	3.86	10.82 lbs.	2.65
5TH F/T	07.12 lbs.	2.74	07.50 lbs.	1.82
MEAN F/T	12.89 lbs.	3.51	12.21 lbs.	2.73
GRIP ENDURANCE	39.65 sec.	12.96	31.53 sec.	10.38
2ND F/T PINCH ENDURANCE	44.16 sec.	21.24	40.70 sec.	28.27

* F/T = FINGER WITH THUMB

Table 5 shows the means and standard deviations of the right hand characteristics including the hand stretch for the female subjects.

The student's t-test analysis was used to compare the characteristics between the group with overuse injury and the group without overuse injury. Table 6 shows the t-test analysis that looked into both male and female hand stretch. Only the male hand stretch showed significant difference between the overuse and non-overuse group.

TABLE 5

RIGHT HAND CHARACTERISTICS FOR FEMALES

	FEMALE OVERUSE GROUP		FEMALE NON-OVERUSE GROUP	
	MEAN	STD.DEV.	MEAN	STD.DEV.
HAND STRETCH	8.93 keys	0.704	8.60 keys	0.632
HAND SPAN	20.53 cm.	1.29	20.20 cm.	0.70
GRIP STRENGTH	75.52 lbs.	10.39	71.31 lbs.	8.10
PINCH STRENGTH				
2ND F/T	12.29 lbs.	2.85	11.40 lbs.	1.64
3RD F/T	12.27 lbs.	3.16	11.69 lbs.	2.13
4TH F/T	08.03 lbs.	2.16	09.03 lbs.	2.10
5TH F/T	04.67 lbs.	1.50	05.33 lbs.	1.11
MEAN F/T	09.31 lbs.	2.00	09.36 lbs.	1.42
GRIP ENDURANCE	25.83 sec.	11.85	25.55 sec.	13.88
2ND F/T PINCH ENDURANCE	32.92 sec.	15.31	39.91 sec.	14.01

* F/T = FINGER WITH THUMB

TABLE 6

T - TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON (R) HAND STRETCH (# keys)

(A) MALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	14	9.2857	0.611	0.163
NON-OVERUSE	10	10.2000	0.919	0.291

$T = -2.93$ $DF = 22$ $P < 0.008$

(B) FEMALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	15	8.9333	0.704	0.182
NON-OVERUSE	15	8.6000	0.632	0.163

$T = 1.36$ $DF = 28$ $P < 0.183$

However, the data for right hand span analyzed by the t - test did not show any significant difference between the 2 groups for both males and females (TABLE 7).

TABLE 7

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON RIGHT HAND SPAN (cm.)

MALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	14	22.1786	1.008	0.269
NON-OVERUSE	10	23.0200	1.447	0.458

$T = -1.68$ $DF = 22$ $P < 0.106$

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	20.5333	1.296	0.335
NON-OVERUSE	15	20.2000	0.702	0.181

$T = 0.88$ $DF = 28$ $P < 0.389$

The grip strength data for both males and females revealed a higher average value for the group with overuse injury. However, when the t-test analysis was done to compare overuse and non-overuse, it showed no significant difference between the groups for either males or females (TABLE 8).

TABLE 8

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON RIGHT HAND GRIP STRENGTH

MALES

	#CASES	MEAN	STD.DEV.	STD. ERROR
OVERUSE	14	117.3786	19.216	5.136
NON-OVERUSE	10	109.0310	16.608	5.568

$T = 1.09$ $DF = 22$ $P < 0.289$

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	75.5293	10.393	2.683
NON-OVERUSE	15	71.3100	8.106	2.093

$T = 1.24$ $DF = 28$ $P < 0.225$

The right hand tip pinch strength, when compared between the overuse and non-overuse groups, revealed a slightly higher average value on the index and middle fingers for both males and females with overuse injury. The pinch strength for the ring and little fingers were higher for the non-overuse group. However, when compared using the t-test analysis, none showed any significant difference. Tables 9, 10, 11 and 12 show the results of the t-test analysis for the index, middle, ring and little finger respectively for both males and females.

TABLE 9

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON TIP PINCH STRENGTH
RIGHT INDEX FINGER

MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	17.2029	4.848	1.296
NON-OVERUSE	10	14.7740	3.051	0.965

T = 1.39 DF = 22 P < 0.177

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	12.2907	2.854	0.737
NON-OVERUSE	15	11.4027	1.643	0.424

T = 1.04 DF = 28 P < 0.305

TABLE 10

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON TIP PINCH STRENGTH
RIGHT MIDDLE FINGER

MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	16.2764	4.400	1.176
NON-OVERUSE	10	15.7450	4.691	1.484

T = 0.28 DF = 22 P < 0.779

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	12.2740	3.162	0.816
NON-OVERUSE	15	11.6913	2.137	0.552

T = 0.59 DF = 28 P < 0.559

TABLE 11

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON TIP PINCH STRENGTH
RIGHT RING FINGER

MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	10.9900	3.866	1.033
NON-OVERUSE	10	10.8220	2.657	0.840

T = 0.12 DF = 22 P < 0.907

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	8.0393	2.165	0.559
NON-OVERUSE	15	9.0313	2.109	0.544

T = -1.27 DF = 28 P < 0.214

TABLE 12

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON TIP PINCH STRENGTH
RIGHT LITTLE FINGER

MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	7.1157	2.749	0.735
NON-OVERUSE	10	7.5040	1.828	0.578

T = -0.39 DF = 22 P < 0.702

FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	4.6740	1.500	0.387
NON-OVERUSE	15	5.3307	1.115	0.288

T = -1.36 DF = 28 P < 0.184

The right hand grip endurance was also compared between the overuse and non-overuse groups. The males in the overuse group were able to maintain the grip longer than those in the non-overuse group, but the difference was non-significant. On the other hand, grip endurance for the females in both groups were the same. Student's t-test analysis for both males and females did not reveal any significant difference (TABLE 13).

TABLE 13

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON RIGHT GRIP ENDURANCE

MALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	14	39.6500	12.966	3.465
NON-OVERUSE	10	31.5310	10.386	3.284

T = 1.64 DF = 22 $P < 0.116$

FEMALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	15	25.8360	11.850	3.060
NON-OVERUSE	15	25.5553	13.885	3.585

T = 0.06 DF = 28 $P < 0.953$

The right tip pinch endurance of the index finger was also compared between the 2 groups. Higher values were seen in the male overuse group and in contrast, higher values were seen in the female non-overuse group. However, both were not significantly different when compared using the student's t-test analysis (TABLE 14).

TABLE 14

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON
RIGHT HAND INDEX TIP PINCH ENDURANCE

MALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	14	44.1600	21.247	5.679
NON-OVERUSE	10	40.7040	28.277	8.942

$T = 0.34$ $DF = 22$ $P < 0.735$

FEMALES

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	15	32.9260	15.313	3.954
NON-OVERUSE	15	39.9167	14.016	3.619

$T = -1.30$ $DF = 28$ $P < 0.203$

The data for the right hand characteristics was subsequently subjected to logistic regression analysis with overuse injury as the dependent variable and the values for the right hand characteristics as independent variables. It revealed no significant relative risk ratio values (TABLE 15).

TABLE 15

LOGISTIC REGRESSION
OVERUSE WITH RIGHT HAND CHARACTERISTICS

	CHI-SQUARE	D.F.	SIGNIFICANCE
-2 LOG LIKELIHOOD	61.663	44	0.0404
MODEL CHI-SQUARE	12.901	9	0.1672
IMPROVEMENT	12.901	9	0.1672
GOODNESS OF FIT	53.063	44	0.1643

	PREDICTED YES	PREDICTED NO	
OBSERVED YES	20	9	68.97%
OBSERVED NO	7	18	72.00%
			OVERALL 70.37%

CONTINUATION OF TABLE 15

VARIABLES IN EQUATION

VARIABLE	B	S.E.	WALD	DF	SIG	R	EXP(B)
RTSTRECH	0.7453	0.6438	1.3401	1	0.2470	0	2.1070
RTSPAN	-0.0772	0.3868	0.0399	1	0.8417	0	0.9257
RTGRPSTR	-0.0292	0.0258	1.2778	1	0.2583	0	0.9712
RTPIN2	-0.1866	0.1929	0.9354	1	0.3335	0	0.8298
RTPIN3	-0.1253	0.1884	0.4424	1	0.5060	0	0.8822
RTPIN4	0.3125	0.2244	1.9395	1	0.1637	0	1.3668
RTPIN5	0.3035	0.2653	1.3088	1	0.2526	0	1.3546
RTGRPEND	-0.0220	0.0242	0.8313	1	0.3619	0	0.9782
RTPINEND	-0.0063	0.0185	0.1168	1	0.7325	0	0.9937
CONSTANT	-2.3739	5.3524	0.1967	1	0.6574		

- NO VALUES WERE SIGNIFICANT -

*** legend ***

B : estimated coefficients
S.E. : standard error
WALD : chi-square test of each variable
DF : degrees of freedom
SIG : significance level
R : test of concordance
EXP (B) : odds ratio

VARIABLES

RTSTRECH : right hand stretch
RTSPAN : right hand span
RTGRPSTR : right grip strength
RTPIN2 : right index finger pinch strength
RTPIN3 : right middle finger pinch strength
RTPIN4 : right ring finger pinch strength
RTPIN5 : right little finger pinch strength
RTGRPEND : right grip endurance
RTPINEND : right pinch endurance

OVERUSE INJURY AND OTHER FACTORS

(1) GENDER

The 54 cases were analyzed according to gender. The results showed slightly higher percentage of males that responded suffered overuse injuries than females. However, the difference was not significant when chi-square analysis was used to compare the overuse and the non-overuse groups according to gender (TABLE 16).

TABLE 16

CHI-SQUARE ANALYSIS
OVERUSE AND NON-OVERUSE BY GENDER

	MALES	FEMALES	TOTAL
OVERUSE	14 (48.3%)	15 (51.7%)	29 (53.7%)
NON-OVERUSE	10 (40.0%)	15 (60.0%)	25 (46.3%)
TOTAL	24 (44.4%)	30 (55.6%)	54 (100%)

CHI-SQ = 0.37241 DF = 1 P < = 0.541697

(2) AGE

Looking at the age difference between the group with overuse and the group without, a student's t-test analysis performed did not reveal any significant difference. Also, when the 2 groups were later broken down according to gender and compared, again no significant difference was noted (TABLE 17).

TABLE 17

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON AGE

A. ALL

	# CASES	MEAN	STD. DEV.	STD. ERROR
OVERUSE	29	21.1724	2.106	0.391
NON-OVERUSE	25	21.4000	3.266	0.653

T = -0.31 DF = 52 P < 0.759

B. MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	21.5000	1.990	0.532
NON-OVERUSE	10	21.6000	2.119	0.670

T = -0.12 DF = 22 P <0.907

C. FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	20.8667	2.232	0.576
NON-OVERUSE	15	21.2667	3.918	1.012

T = -0.34 DF = 28 P < 0.734

(3) YEARS OF PIANO PLAYING

The 2 groups were compared according to the number of years the students had been playing the piano. The student's t-test analysis performed did not show any significant difference between the groups. When the groups were broken down according to gender, the average years of playing for the female overuse group was slightly higher than the male overuse group which was slightly lower, but again no significant difference was shown (TABLE 18).

TABLE 18

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON
YEARS OF PIANO PLAYING

A. ALL

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	29	12.3448	4.253	0.790
NON-OVERUSE	25	12.2000	3.841	0.768

T = 0.13 DF = 52 P < 0.897

B. MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	11.6429	4.845	1.295
NON-OVERUSE	10	12.9000	3.035	0.960

T = -0.72 DF = 22 P < 0.477

C. FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	13.0000	3.665	0.946
NON-OVERUSE	15	11.7333	4.334	1.119

$T = 0.86$ $DF = 28$ $P < 0.395$

(4) LENGTH AND FREQUENCY OF PIANO PRACTICE

It was believed that students with overuse injury might be those that tended to practice long hours. When the 2 groups were compared according to the length of time for piano practice that was usually undertaken, the avarage length was slightly higher for the overuse group but was not significantly different when the student's t-test analysis was performed. The groups were subsequently broken down according to gender and compared, but again, the result showed slightly longer periods of practice sessions for the overuse group but not to a significant degree (TABLE 19).

TABLE 19

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON
LENGTH OF PIANO PRACTICE

A. ALL

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	29	2.1552	1.179	0.219
NON-OVERUSE	25	1.7800	0.925	0.185

$T = 1.29$ $DF = 52$ $P < 0.204$

B. MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	2.5714	1.357	0.363
NON-OVERUSE	10	1.9000	0.937	0.296

T = 1.35 DF = 22 P < 0.191

C. FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	1.7667	0.858	0.222
NON-OVERUSE	15	1.7000	0.941	0.243

T = 0.20 DF = 28 P < 0.841

The frequency of piano practice done per week by the students was analyzed between the overuse and the non-overuse groups. The data for the overall groups as well as when subdivided into males and females showed higher frequency of practice for the overuse group but was not significantly different when the student's t-test analysis was performed (TABLE 20).

TABLE 20

T-TEST ANALYSIS
OVERUSE AND NON-OVERUSE ON FREQUENCY OF PIANO PRACTICE

A.ALL

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	29	10.4483	8.262	1.534
NON-OVERUSE	25	7.2400	3.609	0.722

$T = 1.80$ $DF = 52$ $P < 0.078$

B. MALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	14	10.0000	8.744	2.337
NON-OVERUSE	10	8.0000	3.333	1.054

$T = 0.69$ $DF = 22$ $P < 0.500$

C. FEMALES

	# CASES	MEAN	STD.DEV.	STD.ERROR
OVERUSE	15	10.8667	8.070	2.084
NON-OVERUSE	15	6.7333	3.807	0.983

$T = 1.79$ $DF = 28$ $P < 0.084$

(5) REST PERIODS TAKEN WITHIN EACH PRACTICE SESSION

The 2 groups were compared according to the rest periods taken within each practice session. The majority of the students surveyed were taking rest periods within each practice session. A higher percentage of students in the overuse group took rest periods within each practice session than those in the non-overuse group. However, chi-square analysis did not show any significant difference between the groups. When the data was subsequently broken down according to gender, comparing between the 2 groups, it showed a slightly higher percentage of male students in the overuse group taking rest periods. However, for the females, slightly higher percentage of students in the non-overuse group took rest periods. When a chi-square analysis was carried out, it did not show any significant difference between the groups (TABLE 21).

TABLE 21

CHI-SQUARE ANALYSIS
OVERUSE AND NON-OVERUSE
ACCORDING TO REST PERIODS TAKEN WITHIN PRACTICE SESSION

A. ALL

	REST TAKEN	NO REST TAKEN	TOTAL
OVERUSE	20 (69.0%)	9 (31.0%)	29 (53.7%)
NON-OVERUSE	16 (64.0%)	9 (36.0%)	25 (46.3%)
	36 (66.7%)	18 (33.3%)	N = 54 (100%)

CHI-SQ = 0.14897 DF = 1 P < 0.69953

B. MALES

	REST TAKEN	NO REST TAKEN	TOTAL
OVERUSE	11 (78.6%)	3 (21.4%)	14 (58.3%)
NON-OVERUSE	6 (60.0%)	4 (40.0%)	10 (41.7%)
	17 (70.8%)	7 (29.2%)	N = 24 (100%)

CHI-SQ = 0.97383 DF = 1 P < 0.32373

C. FEMALES

	REST TAKEN	NO REST TAKEN	TOTAL
OVERUSE	9 (60.0%)	6 (40.0%)	15 (50.0%)
NON-OVERUSE	10 (66.7%)	5 (33.3%)	15 (50.0%)
	19 (63.3%)	11 (36.7%)	N = 30 (100%)

CHI-SQ = 0.14354 DF = 1 P < 0.70479

(6) INVOLVEMENT IN SPORTS OR RECREATIONAL ACTIVITIES

The majority of the students surveyed reported that they were involved in some kind of sports or recreational activities. When the 2 groups were compared as well as when they were subdivided according to gender and compared, the chi-square analysis showed higher percentages of students in the overuse group were involved in sports or recreational activities but not to a significant degree (TABLE 22).

TABLE 22

CHI-SQUARE ANALYSIS
OVERUSE AND NON-OVERUSE
ACCORDING TO INVOLVEMENT IN SPORTS/RECREATION

A.ALL

	INVOLVED	NOT-INVOLVED	TOTAL
OVERUSE	23 (79.3%)	6 (20.7%)	29 (53.7%)
NON-OVERUSE	15 (60.0%)	10 (40.0%)	25 (46.3%)
	38 (70.4%)	16 (29.6%)	N = 54 (100%)

CHI-SQ = 2.40109 DF = 1 P < 0.12125

B. MALES

	INVOLVED	NOT-INVOLVED	TOTAL
OVERUSE	11 (78.6%)	3 (21.4%)	14 (58.3%)
NON-OVERUSE	5 (50.0%)	5 (50.0%)	10 (41.7%)
	16 (66.7%)	8 (33.3%)	N = 24 (100%)

CHI-SQ = 2.14286 DF = 1 $P < 0.14323$

C. FEMALES

	INVOLVED	NOT-INVOLVED	TOTAL
OVERUSE	12 (80.0%)	3 (20.0%)	15 (50.0%)
NON-OVERUSE	10 (66.7%)	5 (33.3%)	15 (50.0%)
	22 (73.3%)	8 (26.7%)	N = 30 (100%)

CHI-SQ = 0.68182 DF = 1 $P < 0.40896$

(7) GENERAL TECHNIQUES OR CHARACTERISTICS OF PIANO PLAYING

A. PLAYING STYLE AND MECHANICS

The 2 groups were compared according to the general playing techniques employed looking at finger position and hand tension. All of the non-overuse group employed a curved positioning of the fingers when playing the piano. The majority of injured students also employed a curved finger position, however, 2 (6.9%) of the injured students (1 M , 1 F) reported that they employed a straight finger position when playing the piano (TABLE 23). Chi-square analysis revealed no significant difference between the groups as well as when the 2 groups were subdivided according to gender and compared (TABLE 23).

TABLE 23

CHI-SQUARE ANALYSIS
OVERUSE AND NON-OVERUSE
ACCORDING TO FINGER JOINT POSITION

A.ALL

	CURVED FINGERS	STRAIGHT FINGERS	TOTAL
OVERUSE	27 (93.1%)	2 (6.9%)	29 (53.7%)
NON-OVERUSE	25 (100%)	0 (0%)	25 (46.3%)
	52 (96.3%)	2 (3.7%)	N = 54 (100%)

CHI-SQ = 1.79045 DF = 1 P < 0.18087

B. MALES

	CURVED FINGERS	STRAIGHT FINGERS	TOTAL
OVERUSE	13 (92.9%)	1 (7.1%)	14 (58.3%)
NON-OVERUSE	10 (100%)	0 (0%)	10 (41.7%)
	23 (95.8%)	1 (4.2%)	N = 24 (100%)

CHI-SQ = .74534 DF = 1 P < 0.38796

C. FEMALES

	CURVED FINGERS	STRAIGHT FINGERS	TOTAL
OVERUSE	14 (93.3%)	1 (6.7%)	15 (50.0%)
NON-OVERUSE	15 (100%)	0 (0%)	15 (50.0%)
	29 (96.7%)	1 (3.3%)	N = 59 (100%)

CHI-SQ = 1.03448 DF = 1 P < 0.30911

The majority of volunteer students surveyed reported that the hand stayed relaxed when playing the piano. However, there was a slightly higher percentage of students in the overuse group, males, females or when grouped together, who reported that the hand stayed rigid when playing the piano. A chi-square analysis done to compare the groups according to the tension of the hand employed did not reveal any significant difference between the groups (TABLE 24).

TABLE 24

CHI-SQUARE ANALYSIS
OVERUSE AND NON-OVERUSE
ACCORDING TO HAND & FINGER TENSION WHILE PLAYING

A.ALL

	RELAXED FINGERS	RIGID FINGERS	TOTAL
OVERUSE	23 (79.3%)	6 (20.7%)	29 (53.7%)
NON-OVERUSE	23 (92.0%)	2 (8.0%)	25 (46.3%)
	46 (85.2%)	8 (14.8%)	N = 54 (100%)

CHI-SQ = 1.71310 DF = 1 P < 0.19058

B. MALES

	RELAXED FINGERS	RIGID FINGERS	TOTAL
OVERUSE	11 (78.6%)	3 (21.4%)	14 (58.3%)
NON-OVERUSE	9 (90.0%)	1 (10.0%)	10 (41.7%)
	20 (83.3%)	4 (16.7%)	N = 24 (100%)

CHI-SQ = 0.54857 DF = 1 P < 0.45890

C. FEMALES

	RELAXED FINGERS	RIGID FINGERS	TOTAL
OVERUSE	12 (80.0%)	3 (20.0%)	15 (50.0%)
NON-OVERUSE	14 (93.3%)	1 (6.7%)	15 (50.0%)
	26 (86.7%)	4 (13.3%)	N = 30 (100%)

CHI-SQ = 1.15385 DF = 1 P < 0.28275

B. CHARACTERISTICS OF PIANO PLAYING

The 2 groups were compared according to the general characteristics of piano playing. The repertoire and technical study they concentrate on; the hand they emphasized on training; the method of practicing their repertoire; and, the employment of any physical exercise regimen for the hand prior to piano practice were compared between the 2 groups (TABLE 25). No major difference in percentages was seen between the groups. The students from the different groups practiced the piano in relatively the same manner except that a higher percentage of students in the overuse category played with normal speed and volume.

TABLE 25

GENERAL TECHNIQUES AND CHARACTERISTICS OF PIANO PLAYING

	OVERUSE GROUP	NON-OVERUSE GROUP
REPERTOIRE		
BAROQUE	3.4%	4.0%
CLASSIC	10.3%	20.0%
ROMANTIC	10.3%	8.0%
20TH CENTURY	6.9%	12.0%
POP	13.8%	16.0%
ROCK	10.3%	16.0%
JAZZ	20.7%	28.0%
RYTHM & BLUES	6.9%	4.0%
MIXTURE OF ALL	65.5%	52.0%
TECHNICAL STUDY	86.2%	84.0%
HAND CONCENTRATION ON TECHNICAL STUDY	RIGHT - 17.2% LEFT - 6.9% EQUAL - 62.1% NONE - 13.8%	RIGHT - 20.0% LEFT - 12.0% EQUAL - 56.0% NONE - 12.0%
TECHNIQUES		
OCTAVES	48.3%	44.0%
ARPEGGIOS	58.6%	56.0%
TRILLS	41.4%	24.0%
SCALES	82.8%	80.0%
3RD / 6TH	37.9%	24.0%
CHORDS	44.8%	28.0%
OTHERS	6.9%	08.0%
HAND MOVEMENT IN PLAYING CHORDS/ SCALES	WRIST - 13.8% FOREARM - 24.1% COMBINED - 62.1%	WRIST - 28.0% FOREARM - 20.0% COMBINED - 52.0%
PHYSICAL REGIMEN EMPLOYED	20.7%	20.0%
MANNER OF PRACTICE		
SLOWLY	69.0%	76.0%
NORMAL SPEED	58.6%	28.0%
SMALL UNITS	79.3%	72.0%
NORMAL VOLUME	58.6%	36.0%
FOR ENDURANCE	27.6%	12.0%
SEVERAL TIMES	69.0%	72.0%

(8) HABIT OF PRACTICING WITH PAIN

Finally, on comparing the 2 groups with regards to continuing to practice in the presence of pain, it was seen that 6 females out of the 25 non-overuse group practiced beyond the onset of discomfort. The majority of the students in the overuse group continued practicing even with the onset of discomfort. A chi-square analysis showed significant differences between the groups (TABLE 26A). When the 2 groups were subdivided into males and females, the males showed significant difference between the overuse and the non-overuse groups, with the overuse group continuing to practice beyond the onset of discomfort (TABLE 26B). The females, on the other hand, did not show any significant difference between the 2 groups as 6 female students from the non-overuse group reported that they continue practicing beyond the onset of discomfort (TABLE 26C).

TABLE 26

CHI-SQUARE ANALYSIS OVERUSE AND NON-OVERUSE ACCORDING TO PRACTICING WITH PAIN

A.ALL

	PRACTICING WITH PAIN	NOT PRACTICING WITH PAIN	TOTAL
OVERUSE	20 (69.0%)	9 (31.0%)	29 (53.7%)
NON-OVERUSE	6 (24.0%)	19 (76.0%)	25 (46.3%)
	26 (48.1%)	28 (51.9%)	N = 54 (100%)

CHI-SQ = 10.87325 DF = 1 P < 0.00098

B. MALES

	PRACTICING WITH PAIN	NOT PRACTICING WITH PAIN	TOTAL
OVERUSE	11 (78.6%)	3 (21.4%)	14 (58.3%)
NON-OVERUSE	0 (0%)	10 (100.0%)	10 (41.7%)
	11 (45.8%)	13 (54.2%)	N = 24 (100%)

CHI-SQ = 14.50550 DF = 1 P < 0.00014

C. FEMALES

	PRACTICING WITH PAIN	NOT PRACTICING WITH PAIN	TOTAL
OVERUSE	9 (60.0%)	6 (40.0%)	15 (50.0%)
NON-OVERUSE	6 (40.0%)	9 (60.0%)	15 (50.0%)
	15 (50.0%)	15 (50.0%)	N = 30 (100%)

CHI-SQ = 1.20000 DF = 1 P < 0.27332

CHAPTER V

DISCUSSION

RESPONSE RATE

The response rate was observed to be in the high range for the population studied. Past research has reported an average of 30 to 50 % response rate among musicians. One factor that influenced the response rate might have been the status of the musician at the time of the survey. Professional musicians might be more apprehensive about disclosing their physical discomforts, fearing repercussion from the musical community, as the public might not give the same attention to an "injured" musician. However, fear of repercussion would not be such a problem when surveying students, because most students have not yet started to play music as the source of their livelihood. From this study, it was seen that the majority of the student volunteers, like their professional counterparts, have quite a busy lifestyle. They practiced in sessions averaging 1 to 2 hours, 7 to 10 times a week. In addition, there were classes they had to attend, either related to piano playing, which would mean additional hours at the piano, or any other courses in their program of study. Some of these students were also involved in part-time employment.

The response rate varied from one college to the next, it was observed that institutions wherein the piano professors were quite interested netted higher number of volunteers. Having a list of potential volunteers certainly added to the higher response rate since some students who were interested simply forgot about the study due to their busy schedules.

PREVALENCE

Not surprisingly, the overall prevalence of overuse injury was 53.7%, more than half of the student volunteers surveyed. It is believed that the figure would be even higher if some of the students who expressed their desire to volunteer were able to participate in the study. One from the University of Alberta and 4 from Grant MacEwen Community College were unable to participate within the time frame when data was being collected due to ongoing clinical manifestation of an overuse injury and concurrent therapy being received.

Forty-five out of the total 107 students from the population pool did not respond to the invitation. Just as in previous research, there might be a variety of reasons for this non-response. Since students have a busy schedule, if they do not have any discomfort, or do not know someone having discomfort, they may not be interested in giving their time to a study. It was observed that the first few volunteers from each institution were those who had some kind of discomfort.

DEMOGRAPHIC CHARACTERISTICS

Past research has reported more right handed discomfort for the pianist, especially involving the 4th and 5th fingers. However, in this study, the majority of the complaints were found bilaterally followed by just the right hand and finally the left. Out of the original 34 who complained of overuse injury, 21 (61.76%) presented with bilateral involvement, 8 (23.52%) showed isolated right hand involvement and 5 (14.7%) showed isolated left hand involvement. Although for pianists, the right hand often plays fast melodic passages, some other factor might be involved that would lead to left hand involvement. Hand dominance did not seem to be a factor, since majority of the volunteers were right hand dominant and equally showed overuse injury in both upper limbs.

Playing some other instrument was not found to be a factor influencing the prevalence of overuse injury in this study. Fifty-six percent of the non-overuse and 58.6% of the overuse groups played some other musical instrument such as strings, percussion or even wind instruments.

Forty-one percent of the injured group reported to have had an arm or hand injury in the past as opposed to 12% from the uninjured group. This difference could mean a predisposition of previously injured individuals for recurrence of injury.

CLINICAL SIGNS AND SYMPTOMS

When the signs and symptoms presented by the injured group were examined, it was expected that majority would complain of some kind of pain, and as expected, pain was noted in every case. In fact, in some cases, it was the only complaint noted. The complaint of stiffness was unexpectedly high, since as one moves an extremity, it usually tends to loosen up. However, as fatigue sets in with lengthy practice sessions, it could lead to the development of increased tension to be able to finish the piece of music. This increased tension might result in the feeling of stiffness after the practice.

Two students complained of other symptoms which included the feeling of "cutting off circulation" and paralysis to the hands. As expected, prolonged writing was reported to be the most common activity that brought out the same clinical manifestations as experienced in piano playing. Possibly the same mechanics bringing forth fatigue and increased tension causing discomfort are shared between those two activities.

RIGHT HAND CHARACTERISTICS

Past research had suggested that females are more flexible than males (Larsson et al, 1987; Wagner, 1988; Lee, 1990). However, in this study, general flexibility did not influence the students surveyed. Although hypermobility was not specifically measured in this study, hand span in centimeters and hand stretch over the keyboard revealed larger values for males than for females.

The hypothesis that students without overuse injuries have larger right hand span was not supported by the results of this study. For the females, the number of keys reached and the hand span measured from the tip of the thumb to the little finger was unexpectedly the same in both groups. However, for the males, the non-injured group was able to reach a significantly greater number of keys comfortably than the injured group. When hand span was measured in centimeters, the non-injured group of males had higher values but the difference was not significant.

The hypothesis that students without overuse injuries have stronger right hand grip and finger with the thumb tip pinch strength was not supported by the results of this study. Also, longer endurance for the right hand grip and index finger tip pinch with the thumb was not seen in students without overuse injuries. In most cases, the strength and endurance values were higher for the overuse than the non-overuse groups. There might be a possibility that injured students had exerted themselves too much every time they practice the piano thereby making their hands stronger. A second possibility might be an inappropriate level of reciprocal strength between the flexors and extensors. If one side overpowered the other side too much, a strain of the reciprocal muscle group might occur. A third possibility might be that injured students have undergone some form of therapy and have been taught exercises to increase their strength after an episode of injury. At the same time, due to the limitation of this type of research design, the author was unable to ascertain the relationship between strength and injury.

In order to look at the relative risk ratio, logistic regression analysis was subsequently used and it did not show any significant values. One factor pointed out was the small number of subjects in looking at all 9 independent variables. When power analysis was initially performed to determine the number of subjects to be targeted, the pinch strength of 4 different fingers was considered as one. Too small a number of subjects (60) was therefore targeted. Analysis was carried out as the initial subjects numbered 62, however, with the exclusion of 8 volunteers, the figure went even lower than that needed to have a significant power for the study. The proper number of subjects needed to obtain a significant power should have been 75.

$$\begin{aligned} \text{As} \quad n &= L / (f)2 + k + 1 \\ &= 16.24 / \; 0.25 + 9 + 1 \\ &= 64.96 + 9 + 1 \\ &= 74.96 \text{ or } 75 \end{aligned}$$

(PLEASE REFER TO PAGE 35 FOR THE LEGEND)

OVERUSE INJURY AND OTHER POSSIBLE FACTORS

On reviewing the other possible factors which might influence the prevalence of overuse injuries among piano students, the hypothesis that students with overuse injury were more likely to be females was not supported contrary to previous research implicating female predominance. It was seen that depending on the population targeted and the response, both gender had the same prevalence rate for overuse injury. In this study, males and females were closely represented as opposed to previous research where the response was predominantly female. The results of this study even showed that the prevalence of overuse injury among males was slightly higher than among females (58.3% vs. 50%).

The hypothesis that students in the overuse category tended to be older was not supported by the results of this study. The mean age between the 2 groups was about the same and the non-overuse group even encompassed older students (18 to 32 years old) as opposed to 17 to 26 years old for the overuse group.

Years of piano playing did not seem to make any difference with regards to prevalence of overuse injury. Both groups encompassed a wide range of 2 to 20 years of piano playing. The findings were not able to support the claim that experience would lead to good habits that would guard the pianist against developing injury. Instead, maybe the right kind of experience is needed that would lead to good habits that might protect against development of injury (Taubman, 1988). Therefore, the hypothesis that students with overuse injury played for less years was not supported by the results of this study.

The hypothesis that students with overuse injury practice frequently for longer hours with little or no rest periods within each practice session was not supported by the findings of this study. Although the difference was non-significant, the students in the overuse group did tend to practice more frequently and for longer hours than the students in the non-overuse group. It is possible that significance might have been achieved if a larger number of students were available in each group. As for the rest periods taken within each practice session, the majority (66.7%) of the students surveyed took rest periods. This finding is good because it means that the students might not push themselves over the limit which might increase the chance of developing overuse injury. However, the results did not show any specific relationship between rest periods and prevalence of overuse injury. It would seem that most students take rest periods as they get tired.

The hypothesis that students with overuse injury were not as involved in sports and recreational activities was not supported by the findings of this study. No significant difference was shown between the groups in terms of physical activity. The majority (70.4%) of the students surveyed were involved in some kind of recreational or sports activity. Involvement in physical activity improves the chances of developing physical well being. As society becomes more focused on healthy lifestyles which include physical activity, it might be seen that student musicians will depart from the sedentary lifestyle typical of musicians of earlier times (Poore, 1887). Even though involvement may increase the chance of sports related injury, which, when associated to the upper extremity, would be detrimental to the pianist, involvement could possibly influence the stamina of the individual in doing daily activities.

There are numerous ways of playing the piano. Most of the students today are taught in programs involving combined schools-of-thought, comprising some of the most advantageous elements from different approaches. Two components of piano technique were examined, involving the finger positioning and tension of the hand employed by the student. Not surprisingly, most of the students played with a relaxed hand and curved fingers. However, there were still some (14.8%) who reported that they were unable to control their hands and tended to tense their hands when playing the piano. Although a higher percentage of students in the non-overuse group played with a relaxed hand, the figures between the groups were not significantly different. Therefore, the hypothesis that students with overuse injuries played with an awkward hand positioning was not supported by the findings of this study.

The students in both groups played a mixture of music from different eras ranging from classical to modern music. The majority of them practiced some form of technical study emphasizing both hands. Scales were perceived to be the most difficult and the most commonly practiced technical study for both groups, followed by arpeggios. However, it is interesting that a higher percentage of the overuse group practice chords and trills as opposed to the non-overuse group. Only a minority of the students from both groups employed any set physical exercise regimen prior to playing the piano. This finding was not surprising as the majority believed that hand exercises at the piano are most effective.

It was interesting to see that a higher percentage of students with overuse injury practice their repertoire at normal speed and volume. It has been suggested that when practicing, one should start slowly and gently in order to familiarize oneself with the piece of music before playing at normal tempo. Therefore, this action might have an effect with regards to over-exertion while practicing.

The only significant factor that differentiated between the overuse and the non-overuse groups was the habit of practicing beyond the onset of pain. Sixty-nine percent of the students in the overuse group continued to practice even with the onset of pain. Therefore, the hypothesis that students with overuse injuries tended to practice through the sessions with pain was substantiated by the results of this study. Playing with pain is a poor habit as it can possibly lead to the aggravation of an inflammatory response of the tissues. Pain or discomfort are good indicators of some kind of injury to the tissue structure. They indicate that rest is needed for the tissue to replenish its nutrients and energy, as well as to allow time for the tissue to heal. As one pushes oneself beyond the comfort zone, one increases the chance of possibly experiencing injury.

It was seen that majority of the students took breaks within each practice session. However, they might not be taking breaks at the right time since a large number of them practice beyond their comfort zone.

Although this study was not able to support many of the hypothesized factors that might be associated with overuse injury among piano students, it was able to examine the prevalence among the post-secondary music institutions in the Edmonton area and test some of the different theories regarding injuries experienced by a pianist.

From the results of the different students' T-test and chi-square analyses, it was seen that many of the factors approached significance. For the right hand characteristics, female hand stretch, male hand span, male index tip pinch strength, female little finger tip pinch strength and male grip endurance were very close to significance. The frequency of piano playing, both for the females and the combined group; the involvement in sports or recreational activities, for the males and the combined group; the finger joint and hand tension, for the combined males and females, were all close to significance. Therefore, it might be possible to reach significance if more subjects were available.

RELEVANCE

Musculoskeletal overuse injuries among pianists has been reported in the literature, and numerous factors have been identified and investigated such as gender, flexibility, practice time and intensity that predispose to their development (Poore, 1887 ; Hochberg et al, 1983 ; Dawson, 1988 ; Revak, 1989 ; Hartsell & Tata, 1991 ; Branfonbrener, 1991). Inherent strength of the hand was one such factor suspected (Manchester,1988 ; Hartsell & Tata, 1991). However, no studies had been done that looked specifically into the association of hand muscle strength and the occurrence of musculoskeletal overuse injuries among pianists.

In this study, strength was not found to be associated with the prevalence of overuse injury. However, the subjects in the overuse group tended to have higher strength values than those in the non-overuse group, which might suggest over-exertion to begin with, or inappropriate reciprocal muscle strength between the flexors and extensors, or a training effect after an episode of injury. Upper extremity strengthening exercises therefore might help to protect musicians from redevelopment of overuse injuries.

This study found that students with overuse injury tended to practice beyond the comfort zone. It therefore might be good practice to remind students to rest at the right time and not push oneself beyond the comfort zone in order to reduce the chance of overuse injury.

CHAPTER VI

CONCLUSION

This cross-sectional research study examined the prevalence rate of overuse injuries among the piano students enrolled in 5 post-secondary institutions within the Edmonton area. As expected, about half of the volunteer subjects (53.7%) were classified as having overuse injury.

The association of the primary factor of hand strength and endurance to the prevalence of overuse injury was not able to be substantiated with the results obtained from this study. In contrast to the hypothesis, it was observed that the strength and endurance of the students in the overuse group were greater as opposed to the non-overuse group.

Hand stretch over the keyboard for males was found to be a significant factor that would lend some protection against the development of injury.

In examining the other possible factors that might be associated with overuse injury among piano students, the study was unable to support previous claims of female predominance with overuse injury. Also, the age of the pianist as well as the experience did not seem to influence the prevalence rate of overuse injury. This study was able to show some association with regards to higher number of hours and higher frequency of practice for the overuse group though not to a significant degree. The survey did show that the students had good habits with regards to taking rest periods within practice sessions and being involved in physical activity to maintain a healthy lifestyle and physical well-being. However, further education is needed so that the students know when to take rest periods since a majority of them still practice beyond their comfort zone.

The study showed that more pianists played with a relaxed hand position. The importance of playing with a technique that is most advantageous to the physical restraints of the body was realized by piano students and teachers alike. However, there were still some students who tended to tense up when playing the piano, although this factor could not be associated with the prevalence of overuse injuries in this study.

Finally, the study was able to significantly differentiate the 2 groups with regards to the habit of practicing with pain. It was observed that the overuse group tend to practice beyond the onset of discomfort which, of course, would increase their chance of developing an overuse injury.

RECOMMENDATION

This study only looked into a particular aspect of piano playing technique and there are numerous other technical factors that should be considered in the development of good playing habits. In order to properly look into the different technical aspects, it is recommended that a larger study sample be instituted together with a more indepth review of different piano playing techniques.

Further research into this area needs to be done. It is recommended that a prospective study be undertaken to look into physical as well as technical factors of piano playing which might predispose a pianist to the development of overuse injury.

CLINICAL SIGNIFICANCE

It was seen from the results of this study that students with overuse injuries tended to practice beyond their comfort zone. It would be a good practice to educate and remind students to take rest periods at the proper time, impressing upon the students the consequences of pushing their body tissues beyond what they can do. Proper rest periods as well as the development of physical well being through involvement in sports or recreational activities would help build up the students' body to meet the daily demands of being a pianist.

This study looked at a single aspect of piano playing technique, i.e. hand position & tension. Experience with the proper kind of technique plays an important role. Physiologically sound piano playing technique and practice habits should be learned and undertaken by the students in order to minimize the chance of developing overuse injuries.

It is important not to over-exert oneself when practicing the piano. High levels of speed and volume, if not properly controlled, can cause tension and the development of injury. Also, proper proportional development of the muscle strength through sports involvement might be needed in order to minimize the chance of overstraining reciprocal muscle groups.

REFERENCES

Adlam, D (1981). The Anatomy of the Piano. In Gill, D (ed). The Book of the Piano. Cornell University Press, New York.

Baird,C M (1986). A Pianist's Techniques of Rehabilitation. Med Prob Perform Arts 1 (4) : 128 -130

Bard, C C ; Sylvestre, J J & Dussault, R G. (1984). Hand Osteoarthropathy in Pianist. J Can Assn Radiol. 35 : 154-158

Beighton; Grahame & Bird (1989). Hypermobility of Joints. Springer-Verlag, Berlin.

Bejjani, F J ; Stuchin, S ; & Winchester, R. (1984a). Effect of Joint Laxity on Musicians Occupational Disorders. Clinical Research 32 : 660A

Bejjani, F J ; et al (1989). Comparison of three Piano Techniques as an Implementation of a Proposed Experimental Design. Med Prob Perform Arts 4 (3) : 109-113

Bejjani, F J ; Nilsson, B; & Kella, J J (1984b). Effect of the Instrument on the Musician's Musculoskeletal System. International Conference on Occupational Ergonomics. May 7-9, 1984 . Toronto.

Bird, H A (1984). Overuse Injuries in Musicians. Br Med J 298 : 1129-1130

Bird, H A & Wright, V (1981). Traumatic Synovitis in a Classical Guitarist - A Study of Joint Laxity. Ann Rheum Dis 40 : 161-163

Brandfonbrener, A G (1989). Women in Music: The Weaker Sex ? editorial. Med Prob Perform Arts 4 (1) : 1-2

Brandfonbrener, A G (1990). Joint Laxity in Instrumental Musicians. Med Prob Perform Arts 5 (3) : 117-120

Brandfonbrener, A G (1991). Epidemiology of the Medical Problems of Performing Artists. pp 25-70. In Sataloff,R T et al (eds). Textbook of Performing Arts Medicine. Raven Press, New York

Bystrom, S E G & Kilbom, A (1990). Physiological Response in the Forearm During and After Isometric Intermittent Handgrip. Eur J Appl Physiol 60 : 457-466

Caldorn, P A ; et al (1986). A Survey of Musculoskeletal Problems Encountered in High Level Musicians. Med Prob Perform Arts 1 (4) : 136-139

Chleboun, G S & Berenson, G J (1989). Decreased Flexibility of the First Lumbrical. A Case Study. Med Prob Perform Arts 4 (2) : 86-90

Chong, J; et al (1989). Occupational Health Problems of Musicians. Can Fam Physician 35 (Nov.) : 2341 - 2348

Chung, I S; et al (1992). Wrist Motion Analysis in Pianists. Med prob Perform Arts 7 (1) : 1-5

Cohen, J & Cohen P (1983). Applied Multiple Regression / Correlation Analysis for the Behavioral Sciences. 2nd ed. Lawrence erlbaum Associates, Publishers. Hillsdale, New Jersey.

Dawson, W J (1988). Hand and Upper Extremity Problems in Musicians : Epidemiology and Diagnosis. Med Prob Perform Arts 3 (1) : 19-22

Dawson, W J (1990). Upper Extremity Injuries in High-level Instrumentalists : An End-result Study. Med Prob Perform Arts 5 (3) : 109-112

Eaton, R G & Nolan, W B (1991). Diagnosis and Surgical Treatment of the Hand. In Sataloff, R T; et al (eds). Textbook of Performing Arts Medicine. Raven Press, New York.

Fess, E E (1987). A Method for Checking Jamar Dynamometer Calibration. J of Hand Therapy 1 (Oct.-Dec.) : 28-32

Fess, E E & Moran C A (1981). American Society of Hand Therapist : Clinical Assessment Recommendations. The Society, Garner, North Carolina.

Fess,E E (1990). Documentation : Essential Elements of an Upper Extremity Assessment Battery. pp. 53-81 In Hunter, J M ; et al (eds). Rehabilitation of the Hand - Surgery and Therapy. CV mosby Company, St. Louis, Missouri

Fine, L (1987). The Piano Book. Brookside Press, Massachusetts.

Fishbein,M ; et al (1988). Medical Problems Among ICSOM Musicians: Overview of a National Survey. Med Prob Perform Arts 3 (1) : 1-8

Fletcher, R H et al (1988). Clinical Epidemiology. The Essentials, 2nd ed. Williams & Wilkins. Baltimore, Maryland

Francis,H ; March,L & Webb,J (1987). Benign Joint Hypermobility with Neuropathy : Documentation and Mechanism of Tarsal Tunnel Syndrome. J Rheum 14 (3) : 577-581

Fry, H J H (1986a). Overuse Syndrome of the Upper Limb in Musicians. Med J Aust. 144 : 182-185

Fry,H J H (1986b). Incidence of Overuse Syndrome in Symphony Orchestra. Med Prob Perform Arts 1 (2) : 51-55

Fry, H J H (1986c). Overuse Syndrome in Musicians : Prevention and Management. Lancet Sept. 27, 1986. : 728-731

Fry, H J H (1986d). Overuse Syndrome in Musicians - 100 Years Ago. Med J Aust 145 : 620-625

Fry, H J H (1987). Prevalence of Overuse (Injury) Syndrome in Australian Music Schools. Br J Ind Med 44 : 35-40

Fry, H J H (1988). The Treatment of Overuse Syndrome in Musicians. Results in 175 Patients. J Roy Soc Med 81 : 572-573

Fry, H J H & Rowley, G L (1989). Music Related Upper Limb Pain in School Children. Ann Rheum Dis 48 : 998-1002

Gat, J (1958). The Technique of Piano Playing. Athenaeum Printing House. Budapest

Goodman,G & Staz, S (1989). Occupational Therapy for Musicians with Upper Extremity Overuse Syndrome. Med Prob Perform Arts 4 (1) : 9-14

Grieco, A ; et al (1989). Muscular Effort and Musculoskeletal disorders in Piano Students : Electromyographic, Clinical and Preventive Aspects. Ergonomics 32 (7) 697-716

Harding, D C ; Brandt, M D; & Hillberry, B M (1989). Minimization of Finger Joint Forces and Tendon Tensions in Pianists. Med Prob Perform Arts 4 (3) : 103-108

Harman, S (1982). Occupational Diseases of Instrumental Musicians, Literature Review. Maryland Med J 31 (6) : 39-42

Harman, S (1991). The Evolution of Performing Arts Medicine as seen Through the Literature. In Sataloff, R T ; et al (eds). Textbook of Performing Arts Medicine. Raven Press, New York

Hartsell, H D & Tata, G E (1991). A Retrospective Survey of Music-Related Musculoskeletal Problems Occuring in Undergraduate Music Students. Physio Can 43 (1) : 13-18

Henson, R A & Urich, H (1978). Schumann's Hand Injury. Br Med J 1 : 900-903

Heyward, V H (1975). Relationship Between Static Muscle Strength and Endurance : An Interpretive Review. Am Corr Ther J 29 (3) : 67-72

Heyward, V H (1984). Designs for Fitness. Burgess Publishing Company, Minneapolis

Hmelnitsky, I & Nettheim, N (1987). Weight - Bearing Manipulation : A Neglected Area of Medical Science Relevant to Piano Playing and Overuse Syndrome. Med Hypotheses 23 : 209-217

Hochberg, F H ; et al (1983). Hand Difficulties in Musicians. J A M A 249 (14) : 1869-1872

Hochberg, F H (1990). The Upper Extremity Difficulties of Musicians. In Hunter, J M ; et al (eds). Rehabilitation of the Hand - Surgery and Therapy. C V Mosby Company. St. Louis, Missouri

Hoppman, R A & Patrone, N A (1989). A Review of Musculoskeletal Problems in Instrumental Musicians. Sem Arth & Rheum 19 (2) : 117-126

Hosmer,D W & Lemeshow, S (1989). Applied Logistic Regression. John Wiley & sons, Inc. New York.

Johnson,C D (1990). Grip and Pinch Strength of Musicians. The ASHT 12th Annual Meeting. Sept. 8-12,1989. Seattle, WA

Kahn, H A (1983). An Introduction to Epidemiologic Methods. Oxford University Press, New York

Kella, J J (1989). A Guide to Preventing Musicians' Occupational Injuries. Allegro Health Supplement (April) : 15-19

Kennedy, M (1980). The Concise Oxford Dictionary of Music 3rd ed. Oxford University Press, London.

Kilbom, A (1988). Isometric Strength and Occupational Muscle Disorders. Eur J Appl Physiol 57 : 322-326

Knishkowy,B & Lederman, R J (1986). Instrumental Musicians with Upper Extremity Disorders : A Follow-up Study. Med Prob Perform Arts 1 (3) : 85-89

Kochevitsky, G (1967). The Art of Piano Playing. Summy-Birchard Company. Evaston, Illinois

Larsson,L G ; Baum, J & Mudholker, G S (1987). Hypermobility : Features and Differential Incidence Between Sexes. Arth & Rheum 30 (12) : 1426-1430

Last, J (1980). Freedom in Piano Technique. Oxford Univ Press, London.

Lederman,R J & Calabrese, L H (1986). Overuse Syndrome in Instrumentalists. Med Prob Perform Arts 1 (1) : 7-11

Lederman, R J (1986). Nerve Entrapment Syndromes in Instrumental Musicians. Med prob Perform Arts 1 (2) : 45-48

Lee, S H (1990). Pianist's Hand Ergonomics and Touch Control. Med Prob Perform Arts 5 (2) : 72-78

Lieberman, J L (1989). You are Your Instrument - Muscular Challenges in Practice and Performance. Strings (Nov./Dec.) : 48-50

Lippmann, H I (1991). A Fresh Look at the Overuse Syndrome in Musical Performers : Is "Overuse" Overused ?. Med Prob Perform Arts 6 (2) : 57-60

Lockwood, A H (1988). Medical Problems in Secondary School Aged Musicians. Med Prob Perform Arts 3 (4) : 129-132

Manchester, R A (1988). The Incidence of Hand Problems in Music Students. Med Prob Perform Arts 3 (1) : 15-18

Mandel, S (1990). Overuse Syndrome in Musicians. When Playing on Instrument Hurts. Postgrad Med 88 (2) : 111-114

March,L M ; Francis,H & Weeb, J (1988). Benign Joint Hypermobility with Neuropathy : Documentation and Mechanism of Median, Sciatic and Common Peroneal Nerve Compression. Clin Rheum 7 (1) : 35-40

Mathiowetz,V ; et al (1984). Reliability and Validity of Grip and Pinch Strength Evaluations. J Hand Surg 9A : 222-226

Mathiowetz,V ; et al (1985a). Grip and Pinch Strength : Normative Data for Adults. Arch Phys Med Rehabil 66 : 69-72

Mathiowetz, V ; Rennells, C & Donahoe,L (1985b). Effect of Elbow Position on Grip and Key Pinch Strength. J Hand Surg 10A : 694-697

Mathiowetz, V (1990). Effects of Three Trials on Grip and Pinch Strength Measurements. J Hand Therapy (Oct.-Dec.) : 195-198

Middlestadt,A E & Fishbein, M (1989). The prevalence of Severe Musculoskeletal Problems Among Male and Female Orchestra String Players. Med Prob Perform Arts 4 (1) : 41-48

Moran,C A (1991). Myofascial Approach to Management of Musician's Musculoskeletal Problems. J hand Therapy 5 (Jan-Mar) : 27

Nagai, L & Eng, J (1992). Overuse Injuries Incurred By Musicians. Physiotherapy Canada 44 (1) : 23-30

Newman, W S (1974). The Pianist's Problems. 3rd ed. Harper & Row Publishers. New York

Newmark,J ; et al (1987). Practice Doesn't Necessarily Make Perfect : Incidence of Overuse Syndromes in Amateur Instrumentalist. MedProb Perform Arts 2 (4) : 142-144

Newmark, J & Salmon, P (1990). Playing-related Complaints in Nonclassical Instrumentalists : A Pilot Questionnaire Survey. Med Prob Perform Arts 5 (3) : 106-108

Nolan,W B & Eaton, R G (1989). Thumb Problems of Professional Musicians. Med Prob Perform Arts 4 (1) : 20 -24

Norris, R N (1989). Overuse Injuries - When Practicing Puts You on Hold Instead of Onstage. Guitar Player (Sept.) : 94-98

Ortmann, O (1929). The Physiological Mechanics of Piano Technique. Stephen Austin & Sons Ltd. Great Britain

Oyster,C K ; et al (1987). Introduction to Research. J B Lippincott Company. Philadelphia

Owen, E R (1985). Instrumental Musicians and Repetition Strain Injuries. JOHS-ANZ 1 (2) : 135-139

Patrone, N A; et al (1988). Benign Hypermobility in a Flutist : A Case Study. Med Prob Perform Arts 3 (4) : 20-24

Petersen, P ; et al (1989). Grip Strength and Hand Dominance : Challenging the 10% Rule. Am J Occup Ther 43 (7) : 444-447

Philipson, L ;et al (1990). Muscular Load Levels in Performing Musicians as Monitored by Quantitative Electromyography. Med Prob Perform Arts 5 (2) : 79-82

Poore,G V (1887). Clinical Lecture on Certain Conditions of the Hand and Arm Which Interfere with the Performance of Professional Acts, Especially Piano-Playing. Br Med J Feb. 26,1887 : 441-444

Reid, J G & Thomson J M (1985). Exercise Prescription for Fitness. Prentice-Hall Inc., New Jersey

Revak, J M (1989). Incidence of Upper Extremity Discomforts Among Piano Students. Am J Occup Ther 43 (3) : 149-154

Schmidt,R T & Toews, J V (1970). Grip Strength As Measured By The Jamar Dynamometer. Arch Phys Med & Rehabil (June) : 321-327

Schultz, A (1949). The Riddle of the Pianist's Finger. Carl Fisher Inc. New York

Silverman, R J (1983). Physicians' View of Physical Problems. Piano Quarterly 31 (120) : 42-47

Smith, R D (1982). Paganini's Hand. Arth & Rheum 25 (11) : 1385-1386

Spaulding, C (1988). Before Pathology: Prevention for Performing Artists. Med Prob Perform Arts 3 (4) : 135-139

Taubman,D (1988). A Teacher's Perspective on Musicians Injuries. In Roehmann, F L & Wilson, F R (eds). The Biology of Music Making. MMB Music Inc. Missouri pp. 144-153

Tubiana, R ; Chamagne,P & Brockman,R (1989). Fundamental Positions for Instrumental Musicians. Med Prob Perform Arts 4 (2) : 73-76

Wagner, C H (1971). The Influence of the Tempo of Playing on the Rhythmic Structure Studied at Pianist's Playing Scales. Med & Sport 6 : 129-132

Wagner,C H (1974). Determination of Finger Flexibility. Europ J Appl Physiol 32 : 259-278

Wagner, C H (1987). The Evaluation of the Musicians Hand : An Approach to Prevention of Occupational Disease. In Spintge, R & Droh, R (eds). Music in Medicine. pp. 333-341. Springer-Verlag, Berlin

Wagner, C H (1988). The Pianist's Hand : Anthropometry and Biomechanics. Ergonomics 31 (1) : 97-131

Wagner,C H (1988). Success and Failure in Musical Performance : Biomechanics of the Hand. In Roehmann, F L & Wilson, F R (eds). The Biology of Music Making. pp. 154-179. MMB Music Inc, Missouri

Welkowitz, J ; et al (1982). Introductory Statistics for the Behavioral Sciences. 3rd ed. Academic Press, Florida

Westcott, W L (1987). Strength Fitness. Allyn & Bacon Inc., Massachusetts

Williams J H; Barnes, W S & Gadberry, W L (1987). Influence of Caffeine on Force and EMG in Rested and Fatigued Muscle. Am J Phys Med 66 (4) : 169-183

Young, V L ; et al (1989). Fluctuation in Grip and Pinch Strength Among Normal Subjects. J Hand Surg 14A : 125-129

Ziporyn,T (1984). Pianist's Cramp to Stage Fright : The Medical Side of Music Making. J A M A 252 (8) : 985-989

APPENDIX A

Prevalence of Non-Musculoskeletal Problems Reported by Orchestra Members at the 1986 ICSOM Survey.

Acquired Dental Malocclusion	3%
Acute Anxiety	13%
Asthma	4%
Chin Rest Sore	11%
Depression	17%
Earaches	7%
Other Ear Problems	13%
Eye Strain	24%
Other Eye Problems	8%
Severe Headaches	10%
Heart Condition	4%
Hemorroids	12%
High Blood Pressure	7%
Inguinal Hernia	4%
Loss of Lip	2%
Loss of Seal	1%
Mouth Lesion	3%
Respiratory Allergies	12%
Sleep Disturbances	14%
Stage Fright	24%
TMJ Syndrome	11%
Ulcer	4%
Varicose Veins	4%
Weight Problems	11%

APPENDIX B

Clinical Findings of Overuse Injuries in Pianist

Pain - Diffuse or Localized

Fatigue

Weakness

Loss of Control

Loss of Coordination

Stiffness

Tightness

Redness

Tingling

Local Tenderness

Swelling

Cramps

Curling/Drooping of Fingers

APPENDIX C

LETTER OF SUPPORT

University of Alberta **Inter-departmental Correspondence**

to Mr David Ong
Department of Physical Therapy
2-10 Corbett Hall

date 21 October 1991

telephone

from W Berg, Chair
Department of Music

facsimile

subject: Masters thesis research: Department of Music piano students

I have consulted with the piano instructors in the Department of Music and they have both said that they have no objections to your speaking to their students about injuries sustained in the course of practising their instruments. As I told you when you came to see me, we will not supply a list of students, but you may put a notice on the third floor bulletin board asking for volunteers for your research. In addition, you may get in touch with Professor Helmut Brauss, FAB 3-3 (492-0597) and Professor Stephane Lemelin, FAB 3-7 (492-0596) to inform them of the objectives and methods of your research and ask for their assistance in encouraging students to take part. You have explained to me that your research does not involve treatment of such injuries but rather an investigation of factors that might be implicated.

The Department of Music therefore supports your thesis proposal and declares its willingness to cooperate. I am assuming that we will be kept informed of changes in the objectives or methodology of the proposal.

Yours sincerely,

Wesley Berg
Chair

cc: H Brauss
S Lemelin

APPENDIX D

VOLUNTEER INFORMATION SHEET

THE ASSOCIATION OF
RIGHT HAND CHARACTERISTICS
AND PRACTICE HABITS
WITH THE PREVALENCE OF
OVERUSE INJURY AMONG PIANO STUDENTS

Overuse injuries associated with playing a musical instrument has slowly been more and more recognized. The purpose of this research is to determine if hand strength and endurance and other factors which are associated to the rate of occurrence of overuse discomfort among piano students.

This study involves 4 parts, the first of which will require the measurement of your maximum grip and tip pinch strength of the right and left hand. Grip strength will be measured using the Jamar Dynamometer and index tip pinch strength will be measured by the pinch meter. Three trials of each kind will be done with a 3-5 minute rest between to guard against fatigue. Secondly, endurance will be measured by holding 50% of the maximum voluntary contraction for as long as possible. Thirdly, hand stretch and finger length will be measured in centimeters by the investigator. The final part involves answering a questionnaire based interview about your piano playing skills and physical condition.

The whole study will involve just 1 session, taking no more than 1 1/2 hours of your time. A mutually convenient time and place can be arranged to obtain this information. This study does not entail any serious injury to you as a subject. However, due to the measurement of strength and endurance, some post-testing soreness may be felt.

You are perfectly free to withdraw from the study at any time without prejudice. Any questions concerning the study will be answered before commencement of the measurement session. All records and data from the study will be kept confidential. If you have any questions, please don't hesitate to contact David Ong at 432-1386 or Dr. David Magee at 492-5984.

CONSENT FORM

THE ASSOCIATION OF
RIGHT HAND CHARACTERISTICS
AND PRACTICE HABITS
WITH THE PREVALENCE OF
OVERUSE INJURY AMONG PIANO STUDENTS

I, ______________________________, freely and willingly consent to participate in this research project.

I have been given satisfactory explanation of the objective of this study, the procedure of which has been thoroughly described to me. I understand that taking part in this study is not a requirement for the fulfillment of my program of study at my educational institution (specify) ______________________________.

I understand that my identity will be kept confidential. I hereby give authority to Mr. David Ong and Dr. David Magee to keep, preserve, use and dispose of the data and findings from this research in any way deemed appropriate for the purpose of the study.

I am aware that I may withdraw my consent and discontinue my participation at any time without prejudice to me.

________________________ ________________________
PARTICIPANT DATE

________________________ ________________________
WITNESS DATE

I have explained and defined the research procedure to which the volunteer has consented to participate.

________________________ ________________________
INVESTIGATOR DATE

APPENDIX E

MEAN GRIP AND TIP PINCH STRENGTH
AGE RANGE 20 - 34 YEARS
(from : Mathiowetz et al,1985a)

GRIP	PINCH
Males	Males
Right = 121 Pounds	Right = 18 Pounds
Left = 108 Pounds	Left = 17 Pounds
Females	Females
Right = 75 Pounds	Right = 12 Pounds
Left = 64 Pounds	Left = 11 Pounds

APPENDIX F

QUESTIONNAIRE

Name : ____________________ Date : ____________

Sex : ______ Age : ______

Handedness : ________

Sports/ Recreational Activities: ______________________

____

____

Year Level of Post Secondary Education : ________

Major : ______________

Primary Instrument : ___________________

Secondary Instrument : _________________

Years of Piano Playing : _______

PHYSICAL CONDITION

Please Describe Your General Physical Condition (physically fit, average, poor-sickly) :

____

____

Have you experienced any hand or arm discomfort related to piano playing ? ___ YES ____ NO

ARE YOU EXPERIENCING ANY ARM OR HAND DISCOMFORT NOW ?
____ YES ____ NO

Have you ever suffered from :

____ Hand Paralysis ____ Arm / Hand Injury

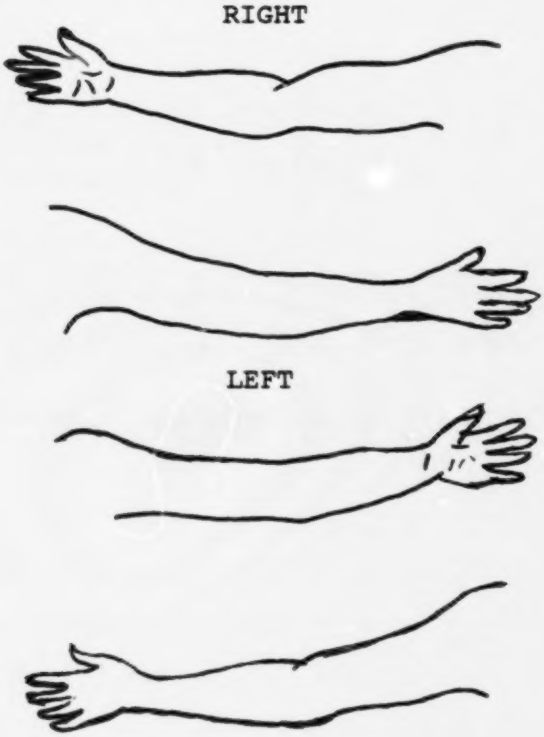
Which of the Following Physical Sensations were Associated with the hand or arm discomfort :

____Pain
____Fatigue
____Swelling
____Redness
____Stiffness
____Pins & Needles
____Weakness
____Tightness
____Cramping
____Loss of Control
____Curling / Drooping
____Other (specify) :
____

Has the hand or arm discomfort ever been caused by :

_____Typing
_____Lifting
_____Using Toothbrush
_____Writing
____Use of Eating Utensils
____Shaking Hands
____Others : _________________________
____

Please indicate on the figure below the precise location of the discomfort if any, within the last 2 years.



Have you seen a physician for your arm or hand discomfort ?
____ YES ____ NO

If yes, were you ever diagnosed as having :

___ Tendinitis
___ Nerve Entrapment Syndrome
___ Posterior Interosseus Nerve Syndrome
___ Cervical Spondylosis
___ Thoracic Outlet Syndrome

___ Carpal Tunnel Syndrome
___ Thoracic Outlet Syndrome
___ Inflammatory Arthritis
___ Dystonia
___ Stretched Tendons
___ Others (specify)
____

PLAYING STYLE

Please Describe as best you can the manner in which you were taught to position your hands when playing the piano :
____
____
____

From which of the following does your repertoire predominantly come from :

___Baroque
___Classic

___Romantic
___20th Century

___Mixture of All
___Others (specify)
____

PLAYING MECHANICS

Do you sit either high or low at the piano ?

___ High ___ Average ___ Low

Do you precede repertoire work with pure technical study ?
___ YES ___ NO

Do you concentrate on one hand more than the other during technical work, and if so, which ?

____ Right ____Left ____ Equal Attention

Do you concentrate on any of the following :

_____Octaves
_____Arpeggios
_____Trills
_____Scales
_____3rds and 6ths
_____Others : ____________________

Is your Octave or Chordal Playing Basically :

____ From the Wrist

____ Combination of Wrist and Forearm

____ From the Forearm

When practicing repertoire, which of the following do you predominantly do : (check more than 1 if desired)

_____Practice slowly
_____Practice at normal speed
_____Practice small units
_____Practice at normal volume
_____Practice for endurance
_____Play through the piece several times

Have you undertaken any physical regimen or set exercises to enhance your piano playing ? ___ YES ___ NO

Specify :____
____

PLAYING HABITS

What is your Average Length (hours/session) and Frequency (session/week) of Practice Sessions ?

______ HRS / SESSION ______ SESSION / WEEK

Do you break up these sessions, and if so, how ? ____________
____

Do you believe that a certain degree of pain is acceptable when attempting to overcome technical difficulties :
____YES ____NO

Have you continued practicing experiencing pain ?
____YES ____NO

HAND MEASUREMENTS

What is Your Hand Stretch on the Keyboard :(R)______(L)______

MEASUREMENT FORM

Hand Span Measurement : (R) _________ (L) _________

STRENGTH MEASUREMENTS

GRIP STRENGTH (POUNDS)

	RIGHT	LEFT
TRIAL 1	___________	___________
TRIAL 2	___________	___________
TRIAL 3	___________	___________
MEAN	___________	___________

PINCH STRENGTH (POUNDS)

	RIGHT				LEFT			
	2ND	3RD	4TH	5TH	2ND	3RD	4TH	5TH
TRIAL 1	___	___	___	___	___	___	___	___
TRIAL 2	___	___	___	___	___	___	___	___
TRIAL 3	___	___	___	___	___	___	___	___
MEAN	___	___	___	___	___	___	___	___

ENDURANCE

	RIGHT	LEFT
GRIP	_________(sec.)	_________(sec.)
INDEX PINCH	_________(sec.)	_________(sec.)

APPENDIX G
RAW DATA

CASE	SEX	AGE	SPTS	HAND	OTIN	YRSPLY	PHYCON	OUI	HXIN	PAIN	FAT	SWELL	RED	STIFF
01	M	21	1	R	1	16	AVE	2	2	2	2	2	2	2
02	M	18	1	R	1	12	FIT	2	2	2	2	2	2	2
03	M	22	1	R	2	06	AVE	2	2	2	2	2	2	2
04	M	23	1	R	1	15	AVE	2	2	2	2	2	2	2
05	M	24	2	R	1	10	FIT	2	1	2	2	2	2	2
06	M	21	2	R	2	14	AVE	2	2	2	2	2	2	2
07	M	22	2	R	2	15	FIT	2	2	2	2	2	2	2
08	M	21	2	R	1	15	AVE	2	1	2	2	2	2	2
09	M	25	1	R	1	14	FIT	2	2	2	2	2	2	2
10	M	19	2	R	1	12	AVE	2	1	2	2	2	2	2
11	F	18	1	R	2	12	AVE	2	2	2	2	2	2	2
12	F	22	1	R	1	03	AVE	2	2	2	2	2	2	2
13	F	19	1	R	1	11	AVE	2	2	2	2	2	2	2
14	F	20	1	R	2	15	AVE	2	2	2	2	2	2	2
15	F	18	2	R	2	11	POOR	2	2	2	2	2	2	2
16	F	19	2	L	1	12	AVE	2	2	2	2	2	2	2
17	F	21	1	R	2	05	AVE	2	2	2	2	2	2	2
18	F	26	1	R	1	20	AVE	2	2	2	2	2	2	2
19	F	21	2	R	2	12	AVE	2	2	2	2	2	2	2
20	F	19	1	R	2	09	FIT	2	2	2	2	2	2	2
21	F	19	1	R	1	10	AVE	2	2	2	2	2	2	2
22	F	21	2	L	1	15	FIT	2	2	2	2	2	2	2
23	F	18	1	L	1	11	AVE	2	2	2	2	2	2	2
24	F	32	1	R	2	12	AVE	2	2	2	2	2	2	2
25	F	26	2	L	2	18	FIT	2	2	2	2	2	2	2
26	M	22	1	L	2	15	AVE	1	2	1	2	2	2	1
27	M	18	1	R	1	11	AVE	1	1	1	2	2	2	2
28	M	20	1	R	1	10	AVE	1	2	1	2	1	2	2
29	M	21	1	R	1	15	AVE	1	2	1	1	1	2	2
30	M	22	1	R	2	07	FIT	1	1	1	1	1	2	1
31	M	21	2	R	1	15	AVE	1	2	1	1	2	2	1
32	M	19	1	R	1	12	AVE	1	1	2	1	2	2	1

CASE	SEX	AGE	SPTS	HAND	OTIN	YRSPLY	PHYCON	OUI	HXIN	PAIN	FAT	SWELL	RED	STIFF
33	M	23	1	R	2	07	AVE	1	2	2	2	2	2	1
34	M	23	2	R	1	12	AVE	1	1	1	1	1	2	1
35	M	20	1	R	2	07	AVE	1	2	1	1	1	2	2
36	M	21	1	R	1	02	AVE	1	1	1	2	2	2	1
37	M	22	2	R	1	12	AVE	1	2	1	2	2	2	2
38	M	20	1	R	1	04	AVE	1	2	2	2	2	2	2
39	M	26	1	R	1	20	FIT	1	1	1	1	2	2	2
40	M	23	1	R	1	18	AVE	1	2	1	2	2	2	2
41	F	19	1	R	1	12	AVE	1	2	1	2	1	2	2
42	F	20	1	R	1	15	AVE	1	2	1	1	2	2	1
43	F	19	1	R	2	10	AVE	1	1	1	2	2	2	1
44	F	21	1	R	1	07	AVE	1	2	1	2	2	2	1
45	F	19	1	R	2	17	FIT	1	2	1	1	1	2	1
46	F	19	1	R	2	08	FIT	1	2	2	2	2	2	1
47	F	22	2	R	2	10	AVE	1	1	1	1	1	2	2
48	F	20	1	R	1	14	AVE	1	2	1	2	2	2	2
49	F	21	1	R	1	10	AVE	1	2	1	1	1	2	2
50	F	26	1	R	2	15	AVE	1	2	1	2	2	2	1
51	F	22	1	L	1	17	FIT	1	2	1	1	1	2	1
52	F	21	1	R	2	16	AVE	1	1	2	2	1	2	2
53	F	22	2	R	1	15	AVE	1	1	1	1	1	1	1
54	F	23	1	R	2	07	AVE	1	1	1	2	2	2	2
55	F	19	1	R	2	10	FIT	1	1	2	2	2	2	1
56	F	23	1	R	1	18	AVE	1	2	1	2	2	2	1
57	F	17	2	R	1	14	FIT	1	2	2	2	2	2	1
58	F	18	1	R	1	08	AVE	1	2	1	1	2	2	2
59	F	19	1	R	2	10	AVE	1	2	1	1	2	2	2

CASE	PIN	WEAK	TIGT	CRM	LCO	DRP	OSS	TYP	LIF	BRU	WRI	EAT	SHA	OAC	LOC	FNJT	TEN
01	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
02	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
03	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
04	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
05	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
06	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
07	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
08	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
09	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
23	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
24	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	N	CU	LX
26	2	1	1	1	1	2	2	1	1	1	1	2	2	2	B	ST	RI
27	2	2	2	2	2	2	1	2	2	2	2	2	2	1	B	CU	RI
28	2	2	1	1	2	2	2	2	2	2	2	2	2	2	R	CU	LX
29	2	1	1	2	2	2	2	2	1	2	1	2	1	1	B	CU	LX
30	2	2	2	2	2	2	2	2	1	2	1	2	2	2	B	CU	LX
31	2	2	1	1	2	2	2	2	1	2	2	2	2	2	B	CU	LX
32	2	1	1	2	2	2	2	2	1	2	1	2	2	2	B	CU	LX
33	1	2	2	2	2	2	2	2	2	2	1	2	2	1	B	CU	LX

CASE	PIN	WEAK	TIGT	CRM	LCO	DRP	OSS	TYP	LIF	BRU	WRI	EAT	SHA	OAC	LOC	FNJT	TEN
34	1	1	2	1	2	2	2	1	1	2	1	2	2	2	B	CU	LX
35	2	1	2	2	2	2	2	2	1	2	2	2	2	2	B	CU	RI
36	2	1	2	2	2	2	1	2	2	2	2	2	2	1	B	CU	LX
37	2	2	2	2	2	2	2	2	2	2	2	2	2	2	R	CU	LX
38	2	2	1	2	2	2	2	2	2	2	2	2	2	2	L	CU	LX
39	2	1	2	2	2	2	2	2	2	2	2	2	2	1	R	CU	LX
40	2	2	2	2	2	2	2	2	2	2	2	2	2	2	B	CU	LX
41	2	1	2	2	2	2	2	2	2	2	1	2	2	2	L	CU	LX
42	2	1	1	2	1	2	2	2	1	2	2	2	1	2	B	CU	LX
43	2	2	2	1	2	2	2	2	2	2	2	2	2	2	B	CU	LX
44	2	2	2	2	2	2	2	2	2	2	2	2	2	2	R	CU	LX
45	2	1	1	1	2	2	2	2	1	2	2	2	2	1	B	CU	LX
46	2	2	1	2	2	2	2	2	2	2	2	2	2	1	L	CU	RI
47	2	2	1	1	2	2	2	2	2	2	1	2	2	2	R	CU	LX
48	2	1	2	2	1	2	2	2	2	1	1	2	2	2	B	CU	LX
49	2	1	2	2	2	2	2	1	2	2	2	2	2	2	L	CU	LX
50	1	2	2	2	2	2	2	1	2	2	1	2	2	1	R	CU	RI
51	1	1	1	2	1	2	2	2	2	2	2	2	2	1	R	CU	RI
52	2	2	1	2	2	2	2	2	2	2	1	2	2	2	R	ST	LX
53	1	1	1	1	1	1	2	1	1	1	1	1	1	1	B	CU	LX
54	2	1	2	1	1	2	2	2	2	2	1	2	2	2	B	CU	LX
55	2	2	2	2	2	1	2	2	2	2	1	2	2	2	B	CU	LX
56	2	2	1	2	1	2	2	2	2	2	1	2	2	2	B	CU	LX
57	2	2	1	1	2	2	2	2	2	2	2	2	2	2	B	CU	LX
58	2	1	2	2	1	2	2	2	1	2	2	2	2	2	L	CU	LX
59	2	2	2	2	2	2	2	2	2	2	2	2	2	2	B	CU	LX

CASE	BAR	CLA	ROM	TWE	POP	ROC	JAZ	R/B	MIX	TEC	HCO	OC	AR	TR	SC	3/6	CH	OTC	MOV
01	2	2	2	2	2	2	2	2	1	1	B	2	2	2	1	2	2	2	W
02	2	1	2	2	2	2	2	2	1	1	B	2	2	2	1	2	2	2	W
03	2	1	2	2	1	1	2	2	2	2	B	2	2	2	2	2	2	2	W
04	1	2	1	2	2	1	1	2	2	1	L	2	1	2	1	2	2	2	C
05	2	2	2	1	2	2	2	2	2	1	B	2	1	2	1	2	2	2	C
06	2	1	2	2	1	1	2	2	2	1	B	2	2	2	1	2	2	2	C
07	2	2	2	2	2	2	1	2	1	1	B	1	1	1	1	1	1	1	C
08	2	2	1	2	2	2	2	2	2	2	N	2	2	2	2	2	2	2	C
09	2	2	2	2	2	2	2	2	1	1	L	1	2	1	1	1	2	2	C
10	2	2	2	1	1	2	2	2	2	2	N	2	2	2	2	2	2	2	F
11	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	F
12	2	2	2	2	2	2	2	2	1	1	R	1	1	2	1	2	2	2	W
13	2	2	2	2	2	2	2	2	1	1	R	2	1	2	1	2	2	2	C
14	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	C
15	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	2	1	2	W
16	2	2	2	2	2	2	1	1	1	1	B	2	1	2	2	2	1	2	W
17	2	2	2	2	2	1	1	2	2	2	N	2	2	2	2	2	2	2	W
18	2	2	2	2	2	2	2	2	1	1	B	2	2	1	1	2	2	2	F
19	2	2	2	2	2	2	1	2	2	1	R	1	2	2	1	2	1	2	C
20	2	1	2	2	1	2	1	2	2	1	B	1	2	2	1	1	2	2	F
21	2	1	2	2	2	2	2	2	2	1	R	1	1	2	1	2	1	1	C
22	2	2	2	2	2	2	2	2	1	1	B	1	1	2	1	1	2	2	C
23	2	2	2	2	2	2	2	2	1	1	L	2	1	2	1	2	2	2	C
24	2	2	2	1	2	2	2	2	2	1	R	1	1	2	1	2	2	2	C
25	2	2	2	2	2	2	2	2	1	1	B	2	2	2	1	2	2	2	F
26	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	W
27	2	2	2	2	2	2	2	2	1	1	B	2	2	2	1	2	1	2	F
28	2	2	2	1	2	2	2	2	2	2	N	2	2	2	2	2	2	2	W
29	1	1	1	2	2	2	2	2	2	1	B	1	1	1	1	2	2	2	F
30	2	2	2	2	2	2	2	2	1	2	N	2	2	2	2	2	2	2	F
31	2	2	2	2	1	1	1	1	2	1	R	2	2	2	1	2	1	2	C
32	2	2	2	2	1	2	2	2	1	1	R	1	1	2	1	2	2	2	C
33	2	2	2	2	1	2	1	2	2	1	B	2	2	2	2	2	2	1	C

CASE	BAR	CLA	ROM	TWE	POP	ROC	JAZ	R/B	MIX	TEC	HCO	OC	AR	TR	SC	3/6	CH	OTC	MOV
34	2	2	1	2	2	2	1	2	2	1	B	2	2	1	1	1	1	2	C
35	2	2	2	2	1	1	1	2	2	2	N	2	2	2	2	2	2	2	C
36	2	2	2	1	2	2	2	2	2	1	B	1	1	1	1	2	1	2	W
37	2	1	1	2	2	2	2	2	2	1	B	1	1	1	1	2	2	2	F
38	2	1	2	2	2	2	1	2	2	1	B	2	2	1	2	2	2	2	C
39	2	1	2	2	1	1	1	1	2	1	R	2	2	1	1	1	2	1	C
40	2	2	2	2	2	2	2	2	1	2	N	2	2	2	2	2	2	2	C
41	2	2	2	2	2	2	2	2	1	1	R	1	1	2	1	1	2	2	W
42	2	2	2	2	2	2	2	2	1	1	B	2	1	2	1	2	2	2	C
43	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	C
44	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	F
45	2	2	2	2	2	2	2	2	1	1	L	2	2	2	1	2	1	2	C
46	2	2	2	2	2	2	2	2	1	1	L	1	1	1	1	1	1	2	F
47	2	2	2	2	2	2	1	2	2	1	B	2	1	2	1	2	2	2	C
48	2	2	2	2	2	2	2	2	1	1	B	1	2	1	1	2	1	2	C
49	2	2	2	2	2	2	2	2	1	1	B	2	2	2	1	2	2	2	C
50	2	2	2	2	2	2	2	2	1	1	B	2	1	2	1	2	2	2	W
51	2	2	2	2	2	2	2	2	1	1	B	1	1	2	1	1	2	2	C
52	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	F
53	2	2	2	2	2	2	2	2	1	1	L	1	1	1	1	1	1	2	C
54	2	2	2	2	2	2	2	2	1	1	R	1	1	2	1	1	2	2	F
55	2	2	2	2	2	2	2	2	1	1	B	2	1	2	1	2	2	2	C
56	2	2	2	2	2	2	2	2	1	1	B	1	1	2	1	1	2	2	C
57	2	2	2	2	2	2	2	2	1	1	R	2	2	2	1	2	1	2	C
58	2	2	2	2	2	2	2	2	1	1	L	1	1	1	1	2	2	2	W
59	2	2	2	2	2	2	2	2	1	1	B	1	1	1	1	1	1	2	C

CASE	SLW	NSP	SMU	NVL	END	SVT	REG	LNTH	FRE	BRK	PRPA	RT#K	RTSPN	RTGRPSTR
01	1	2	1	1	2	1	1	1.50	10	1	2	10	22.90	108.00
02	2	1	2	1	2	1	2	0.50	05	2	2	10	22.00	099.66
03	1	2	1	1	2	1	2	1.00	12	2	2	11	24.90	125.33
04	2	2	1	2	2	2	1	1.50	07	2	2	09	20.50	096.33
05	1	2	2	2	2	1	2	2.00	08	1	2	09	22.80	089.66
06	1	2	1	2	2	2	2	2.50	09	1	2	10	22.40	102.00
07	1	1	1	1	2	1	2	3.00	04	1	2	10	21.60	110.33
08	1	2	1	2	1	2	2	3.00	07	1	2	12	24.50	137.00
09	1	1	1	1	1	1	2	3.00	14	1	2	10	24.30	134.00
10	2	1	2	1	2	1	2	1.00	04	2	2	11	24.30	088.00
11	1	2	1	2	2	2	1	1.00	03	2	2	09	19.40	078.00
12	2	1	1	2	2	1	1	1.00	06	1	1	09	20.50	069.60
13	1	2	1	2	2	1	2	1.00	02	2	1	08	19.80	084.66
14	1	2	1	1	2	1	2	2.00	05	2	2	09	20.50	077.33
15	1	2	1	2	2	2	2	1.50	08	1	2	08	20.10	072.33
16	1	2	1	2	2	1	2	1.00	14	1	2	08	19.80	060.00
17	2	1	2	2	2	1	2	1.00	04	1	2	09	19.90	065.00
18	1	1	1	1	1	1	2	4.00	06	1	2	09	20.90	065.66
19	1	2	1	2	2	1	2	1.00	16	1	2	08	18.70	061.66
20	1	2	1	2	2	1	2	3.00	06	1	2	08	20.90	068.33
21	1	2	2	1	2	1	2	1.50	05	2	2	08	19.50	083.60
22	1	2	2	2	2	1	2	1.50	09	1	1	10	21.00	059.16
23	1	2	1	2	2	2	2	1.00	05	1	1	09	20.50	077.66
24	2	2	2	2	2	1	2	2.00	05	2	1	08	20.20	071.33
25	1	2	1	2	2	2	1	3.00	07	1	1	09	21.30	075.33
26	2	1	1	1	2	2	2	3.00	05	1	1	09	23.00	119.33
27	1	2	1	2	2	1	2	1.00	14	1	2	09	22.80	105.66
28	2	2	1	1	2	1	2	1.00	07	1	2	09	22.00	113.00
29	2	1	1	1	2	1	2	3.00	06	2	2	09	21.00	115.00
30	1	2	1	2	2	1	2	2.50	04	1	1	09	20.00	099.33
31	2	1	2	2	1	1	2	3.00	08	1	1	10	24.00	112.33
32	1	2	1	2	2	1	2	3.00	07	1	1	10	22.30	114.66
33	1	2	1	1	2	2	2	3.00	04	1	1	08	21.90	107.33

CASE	SLW	NSP	SMU	NVL	END	SVT	REG	LNTH	FRE	BRK	PRPA	RT#K	RTSPN	RTGRPSTR
34	1	2	1	1	2	2	2	6.00	06	1	1	10	22.30	118.33
35	2	1	2	2	2	1	1	1.50	21	2	1	10	23.20	173.00
36	2	1	2	1	2	1	2	1.00	35	2	1	09	22.80	133.33
37	1	2	1	2	2	1	2	2.00	06	1	1	09	21.30	090.00
38	2	2	1	2	2	1	2	2.00	07	2	1	09	21.60	127.66
39	1	1	1	2	2	2	2	4.00	03	1	1	09	21.60	126.00
40	2	1	2	1	2	2	2	2.00	14	1	1	10	22.30	116.00
41	1	2	1	2	2	1	2	1.50	07	2	1	08	21.50	095.66
42	2	1	2	2	2	1	2	1.50	05	1	1	09	20.50	077.00
43	1	1	1	1	1	1	1	0.75	06	2	1	08	19.50	072.66
44	1	2	1	2	1	2	1	2.50	12	1	2	08	20.00	066.33
45	1	1	1	2	2	1	2	0.50	35	1	1	09	21.00	095.00
46	2	2	1	2	2	1	2	3.00	06	1	1	08	21.60	078.33
47	1	1	1	1	2	2	2	1.00	10	2	2	08	19.00	060.66
48	1	2	1	1	2	1	2	2.00	04	1	1	09	21.00	080.66
49	1	1	1	1	1	1	1	2.00	10	1	1	09	22.00	069.66
50	1	1	1	1	1	1	2	3.00	05	1	1	10	21.70	085.66
51	1	1	1	1	1	1	1	2.00	14	1	1	09	21.30	081.00
52	2	2	1	1	2	2	1	2.00	11	1	2	09	18.90	077.66
53	1	1	1	1	1	1	1	2.00	12	1	1	10	22.20	060.66
54	1	2	2	2	2	1	2	3.00	07	2	1	09	19.50	081.33
55	1	2	1	2	2	1	2	1.00	08	1	1	09	19.60	060.33
56	1	1	1	1	1	1	2	1.50	04	2	2	08	19.00	087.66
57	1	1	1	1	2	2	2	3.00	09	2	2	09	21.80	075.33
58	1	2	1	2	2	2	1	1.50	07	2	2	09	21.90	081.00
59	1	1	1	1	1	1	2	0.75	21	2	2	10	23.00	071.00

CASE	RTPIN2	RTPIN3	RTPIN4	RTPIN5	RTGRPEND	RTPIN2END
01	19.08	25.66	15.08	10.58	43.41	036.83
02	14.25	14.66	11.91	07.91	29.03	024.20
03	14.50	19.08	11.41	06.75	24.10	024.92
04	15.50	14.66	11.50	06.58	48.31	020.86
05	14.00	14.41	12.50	09.58	17.87	032.34
06	16.25	18.08	12.16	06.91	20.57	042.44
07	11.00	10.66	05.58	04.33	37.93	087.36
08	19.58	17.83	09.00	07.91	29.35	020.85
09	13.58	13.16	11.08	08.66	40.52	020.02
10	10.00	09.25	08.00	05.83	24.22	097.22
11	14.00	12.25	10.08	07.00	14.30	010.98
12	09.58	10.08	09.00	05.83	48.70	056.19
13	12.00	11.08	09.00	03.16	20.43	046.97
14	14.75	16.33	14.41	05.00	16.07	037.88
15	10.58	12.91	12.00	05.75	28.24	046.52
16	09.66	11.25	09.25	05.00	44.41	035.27
17	11.08	10.33	07.58	05.33	36.48	036.87
18	09.08	08.58	07.08	04.58	08.69	032.82
19	12.16	12.91	07.75	05.66	12.49	049.27
20	11.25	12.33	07.75	05.00	32.08	026.72
21	12.41	14.50	09.75	06.41	26.38	025.75
22	09.50	09.08	06.00	04.41	49.81	046.45
23	10.66	11.41	09.83	04.00	17.84	065.50
24	12.25	09.08	07.08	05.33	11.32	028.36
25	12.08	13.25	08.91	07.50	16.09	053.20
26	17.50	15.25	09.08	10.08	42.10	027.64
27	22.16	16.58	12.25	05.00	30.63	017.73
28	18.50	17.16	10.16	06.16	16.32	023.32
29	22.30	20.00	10.50	06.83	37.87	021.82
30	09.41	09.16	06.58	05.50	43.00	034.70
31	13.91	15.33	11.33	06.83	30.27	046.59
32	12.50	11.33	04.66	04.50	47.09	026.03
33	11.91	10.33	06.41	04.08	48.11	048.70

CASE	RTPIN2	RTPIN3	RTPIN4	RTPIN5	RTGRPEND	RTPIN2END
34	16.00	20.66	13.41	07.41	37.81	053.87
35	21.66	23.58	18.08	13.66	19.97	095.51
36	24.00	21.83	17.75	10.58	60.29	047.45
37	14.83	14.75	09.58	07.08	32.68	047.48
38	14.25	11.83	07.25	05.50	18.74	056.63
39	23.41	19.00	12.91	04.00	51.37	062.52
40	12.75	12.91	11.16	07.91	57.59	064.88
41	16.75	11.91	05.91	05.25	31.60	055.94
42	14.25	13.91	08.41	04.41	30.30	030.11
43	17.91	14.91	10.16	03.91	27.74	013.99
44	11.83	09.83	08.16	04.16	30.70	050.19
45	11.58	11.41	06.66	05.33	09.91	029.60
46	12.00	11.08	07.50	04.83	73.35	141.52
47	11.41	09.91	10.33	04.91	07.19	010.29
48	10.25	10.25	06.41	04.75	10.09	041.99
49	11.16	08.66	06.75	05.25	18.45	017.70
50	10.83	08.25	06.16	04.66	35.70	060.79
51	14.83	15.75	07.25	05.25	29.60	025.59
52	10.41	14.33	08.58	04.00	22.66	026.92
53	07.08	07.25	03.41	02.33	27.88	062.16
54	13.83	15.41	10.91	06.50	52.07	036.77
55	09.91	08.25	05.66	01.83	36.73	024.34
56	17.08	14.91	08.16	04.00	17.66	019.29
57	12.50	12.66	09.08	07.66	30.45	028.77
58	12.08	13.33	08.75	06.25	35.35	033.59
59	10.66	17.08	11.25	06.41	18.86	033.09

*** LEGEND ***

CASE : subject number
SEX : gender
AGE : age
SPTS : involvement in sports
HAND : hand dominance
OTIN : other instruments played
YRSPLY : years of piano playing
PHYCON : perceived physical condition
OUI : overuse injury
HXIN : history of past injury
PAIN : clinical manifestation (s/s) of pain
FAT : (s/s) of fatigue
SWELL : (s/s) of swelling
RED : (s/s) of redness
STIFF : (s/s) of stiffness
TIGT : (s/s) of tightness
CRM : (s/s) of cramping
LCO : (s/s) of loss of control
DRP : (s/s) of drooping
OSS : other clinical manifestations (s/s)
TYP : (s/s) during typing
LIF : (s/s) during lifting
BRU : (s/s) during tooth brushing
WRI : (s/s) during writing
EAT : (s/s) with using eating utensils
SHA : (s/s) during hand shaking
OAC : (s/s) during other activities
LOC : location of (s/s)
FNJT : finger joint position
TEN : hand and finger tension
BAR : baroque repertoire
CLA : classical repertoire
ROM : romantic repertoire
TWE : twentieth century repertoire
POP : popular music repertoire
ROC : rock music repertoire
JAZ : jazz music repertoire
R/B : rythm and blues repertoire
MIX : mixture of all repertoire
TEC : technical practice before repertoire practice
HCO : hand concentration during technical practice
OC : octaves (technique)
AR : arpeggios (technique)

*** LEGEND ***

TR : trills (technique)
SC : scales (technique)
3/6 : 3rds & 6ths (technique)
CH : chords (technique)
OTC : other techniques practiced
MOV : site of movement when playing chords or scales
SLW : practice repertoire slowly
NSP : practice at normal speed
SMU : practice small units
NVL : practice at normal volume
SVT : practice for endurance
REG : physical exercise regimen employed
LNTH : length of practice session
FRE : frequency of practice per week
BRK : break period taken within each session
PRPA : habit of practicing with pain
RT#K : right hand stretch over the keyboard (# of Keys)
RTSPN : right hand span
RTGRPSTR : right hand grip strength
RTPIN2 : right index finger pinch strength
RTPIN3 : right middle finger pinch strength
RTPIN4 : right ring finger pinch strength
RTPIN5 : right little finger pinch strength
RTGRPEND : right hand grip endurance
RTPIN2END : right index finger pinch endurance

** NOTE **

1 = YES
2 = NO

CASE NUMBER 38,41,46,49 AND 58 EXCLUDED FROM FINAL ANALYSIS DUE TO LEFT HAND INVOLVEMENT

LOC	:	B = BILATERAL R = RIGHT L = LEFT N = NONE
FNJT	:	CU = CURVED POSITION ST = STRAIGTH POSITION
TEN	:	LX = RELAXED HAND RI = RIGID HAND
HCO	:	R = RIGHT HAND CONCENTRATION L = LEFT HAND CONCENTRATION B = BILATERAL HAND CONCENTRATION N = NONE (NO TECHNICAL STUDY)
MOV	:	W = MOVEMENT FROM THE WRIST F = MOVEMENT FROM THE FOREARM C = COMBINED WRIST AND FOREARM
LNTH	:	(hrs./session)
FRE	:	(session/week)
RT#K	:	(# of keys)
RTSPN	:	(centimeters)
RTGRPSTR	:	(pounds)
RTPIN2 - RTPIN5	:	(pounds)
RTGRPEND	:	(seconds)
RTPIN2END	:	(seconds)